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DUST AVAILABILITY IN DESERT TERRAINS

A STUDY IN THE DESERTS OF ISRAEL AND THE SINAI

BY

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ABSTRACT

The study deals with dust in desert terrains — its composition, distribution and the relation to landforms, climate and age. Most of the dust in deserts is derived from soils and surficial deposits. These, in turn, are associated with landforms that are readily identifiable on airphotos (and in many cases — on topographic maps and space imagery).

Emphasis is placed on particle size distribution, mineral composition, the composition of salts and the distribution with depth. The interrelations with atmospheric dust in and from deserts are underlined.

The largest content of dust is found in loessial soils, Takyr soils and the thick Reg and Hammada soils. Young gravelly alluvium, dune sand and some playa soils are rather poor in dust content. The thickness of the continuous dust-rich layer is greatest in loessial soils and deposits and Takyr soils. The thinest dust horizons are found in young Reg and Hammada soils.

Salts and gypsum are typical constituents in desert soils. Usually there is more gypsum than salts. Both show in the dust and the sand fractions and their content increases with soil depth. The most saline are Solonchak and Reg soils. The least saline are sand dune soils, young gravelly soils and loessial soils in the less arid environments.

The composition and distribution of the dust-sized materials are presented in quantitative terms.

Ground cover/protection is of several types: desert pavement, loessial crusts, biologic crusts and salt crusts. A procedure for evaluation of dust availability in desert terrains accompanies this report.

CONTENTS

PREFACE

Dust in desert terrains is concentrated primarily in soils and surficial deposits. The present study deals mainly with these two media. The deserts of Israel and Sinai are similar in many aspects, such as landforms, deposits and soils, to other hot deserts. The studied terrains represent — in principle and practice — many widespread desert landscapes. Quantitatively, there are certainly some differences, but the reader may use the results of the present study as an approximation for similar terrains elswhere.

We have benefited greatly from the research and analysis presented by many colleagues. We are grateful especially to J. Dan, D.H. Yaalon, H. Koyumdjisky and E. Ganor for providing data, analyses and interpretations in their studies on soils and dust. We have consulted them occasionally.

The help of several collaborators is gladly acknowledged: U. Amit, for data processing and analysis; T. Sopher and N.Z. Baer, for drafting the figures; Are'i Rosen, for assistance in the field and in the laboratory; Arlene Rosen, for editing a portion of the present report; M. Frankel, for word-processing, format editing and printing of this volume.

PART A. INTRODUCTION

A.1 SCOPE AND OBJECTIVES OF STUDY.

The present study aims at assisting a planner to evaluate the availability of dust in desert terrains — on the surface and at a shallow depth. Such an evaluation is important especially in areas for which there is no direct opportunity to examine the landscape in the field.

Dust in deserts is found primarily in surficial deposits and in soils. Such deposits and soils are closely associated with host-landforms. These landforms may be readily interpreted and identified from airphotos, space imagery and maps which are often available for unexplored or inaccessible deserts.

Two objectives underlie the present study:

1. To estimate or evaluate the amount, composition and distribution of dust in desert soils and surficial deposits.

2. To lay the foundation for a procedure for evaluation of dust availability in desert terrains.

The study was carried out in the deserts of southern Israel (the Negev, the Dead Sea Rift, and the Judean Desert) and Sinai, which may serve as a model for other deserts (fig. A.1).

The general setting of the selected desert region is as follows:

1. Lithology (the lithostratigraphy is presented in fig. A.2). Southern Israel, most of the Sinai and southern Jordan, are underlain mainly by carbonate rocks — limestones, dolomites, chalks and marls of upper Cretaceous and Tertiary ages. Shales and flints are exposed in certain (mostly synclinal) areas. Along the margins of the Arava (Rift) Valley there are exposures of sandstones of Paleozoic to lower Cretaceous ages, overlain by carbonate rocks. In the southernmost Negev, eastern and southern Sinai, and southwestern Jordan there are exposures of igneous and metamorphic rocks of Precambrian age — granites, diorites, syenites, various porphyritic rocks, gneisses and schists. Fluviatile gravel is widespread in the plains of the southern Negev and the Arava Valley. Dune fields are located in the northwestern Negev and loessial terrains are typical of the northern margins of the region. A pedologic expression of these later deposits are presented in the soil map, fig. A.3.

2. Physiography and relief. The gross physiographic features of the Negev and the Sinai are related to the following elements and basic conditions: a. Geologic structure: fault escarpments along the Arava Rift Valley and across the central and southern Negev; elevated anticlinal ridges and synclinal depressions; inversions of relief as best exemplified in the deep, escarpment skirted, erosion cirques at the cores of three major anticlinal structures (plate 7A); plateaus, built of flat lying limestones (plates 1B, 7A). b. Stream valleys and hillslopes of mountaineous (>200m in relief and >20° in gradient) or hilly nature (20–200 m in relief and <20° in gradient; plate 8 A–C). These are erosional features which are expressed in all types of cohesive rocks (plates 7–8). c. Escarpments — long and continuous steep slopes formed by faulting and/or erosion, built of limestones overlying chalks and shales, flints overlying chalks or in rather monolithologic terrains along major fault lines. d. Plains (<20 m in relief and <10° in gradient) are characteristically related to graveily, sandy or loessial deposits (plate 1B). e. Badlands which are limited to areas of steep gradients where shales, chalks and loess are exposed (plate 9).

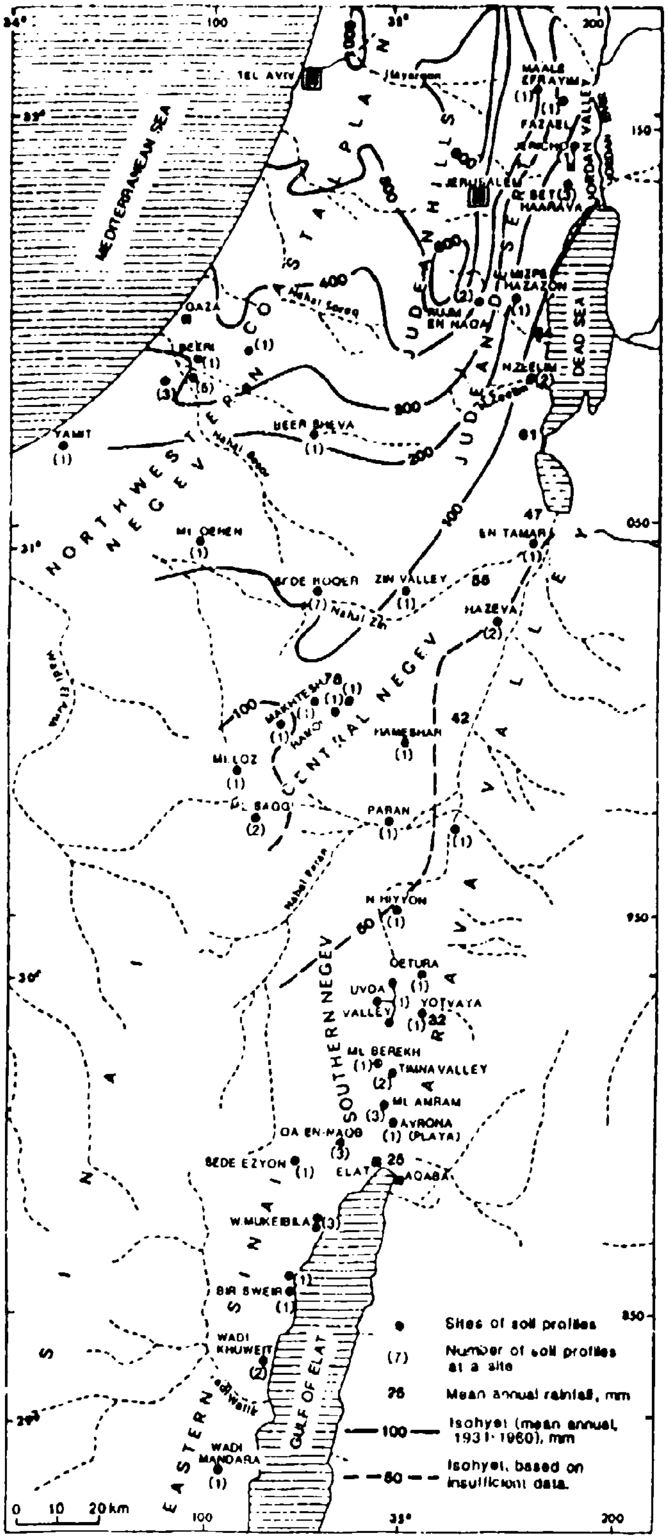
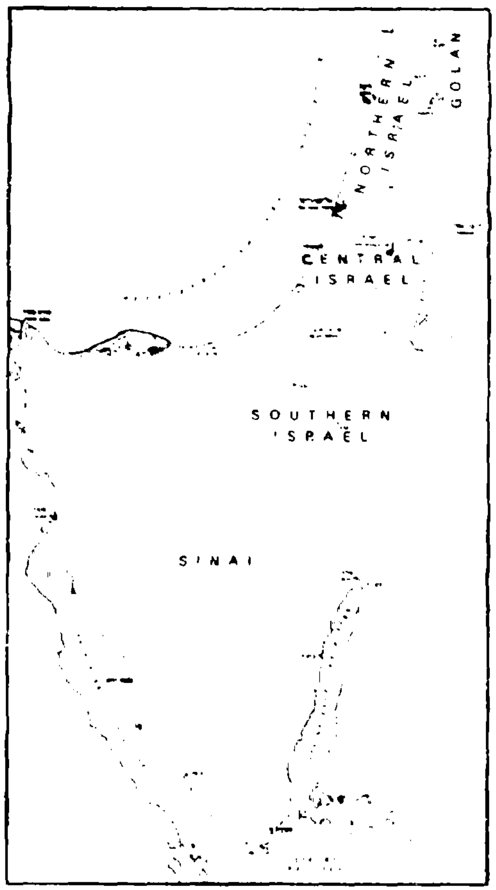


Figure A.1 A location map — The Negev, northeastern Sinai, part of the Dead Sea Rift Valley and the Judean Desert: mean annual rainfall and sites of soil profiles and sections in surficial deposits.

LOCATION MAP



GENERALIZED STRATIGRAPHIC CHART

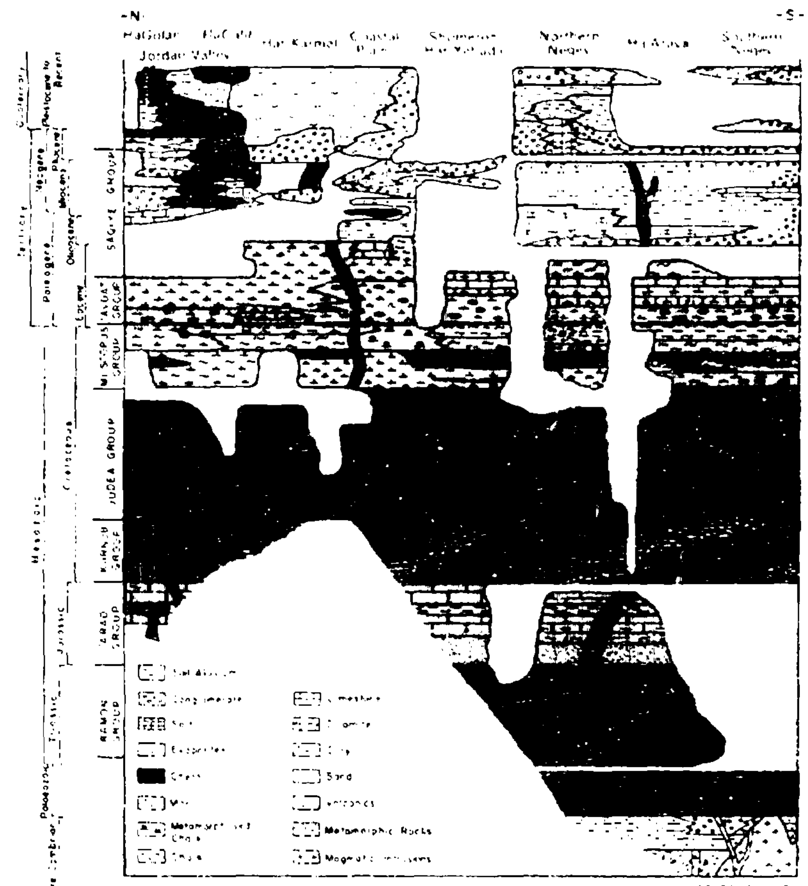


Figure A.2 A general sketch of the lithostratigraphy of Israel (After Bartov et al., 1981). In a very general way, the lithostratigraphy of Israel is similar to that in North Africa and the areas to the east and south east of Israel and the Sinai.

3. Climate. The climatic regimes of the hot arid environment are here subdivided according to the mean annual precipitation as follows (modified from Dan, 1981): a. Semi-arid — 400-250 mm/year; b. Moderately arid — 250-150 mm/year; c. Arid — 150-80 mm/year; d. Extremely arid — <80 mm/year. This subdivision is based on areal distribution of vegetation associations, and geomorphic processes, such as the relative significance of mechanical weathering and diagnostic soil associations.

Most of the Negev and the Sinai is a hot desert under arid and extremely arid climates (fig. A.1). The northern fringes of the Negev are moderately arid, recieving 150-250 mm/year of mean annual precipitation, and having a mean annual temperature of 19-21°C. The northern and central Negev are arid in climate — 80-150 mm/year of average precipitation and 19-21°C in mean annual temperature. The southern Negev and the Arava Valley are drier and hotter: less than 50 mm/year of average precipitation and above 23°C in mean annual temperature. Mean annual relative humidity decreases from 55-60% in the northern Negev, to 40-50% in the southern Negev. Potential evaporation is high: 160-180 cm/year in the northern Negev, and 180-270 cm/year in the southern Negev and in the Arava Valley.

A.2 A GENERAL STATEMENT.

Dust is here defined as material composed of particles smaller than 0.063 mm in diameter. It is the silt (0.063-0.002 mm) and clay (<0.002mm) fractions in both surficial deposits and the atmosphere.

Dust is present in appreciable amounts — usually larger than several percents — at and close to the surface of many desert terrains. Most of the dust is to be found in desert soils and surficial deposits, and in joints between rock blocks. The occurrence of dust as a major component in the exposed bedrock is less frequent. Shale, chalk and mudstone may serve as examples.

The sources of dust in deserts are diversified. Dust may derive from two groups of sources:

1. Primary sources: products of *in situ* rock weathering; volcanic ash; marine aerosols; particles of biogenic, anthropogenic and cosmic sources.

2. Secondary sources: alluvial and colluvial sediments; soils; eolian sediments such as sand dunes and eolian loess; deposits of standing water, as found in playas and dried lakes. These secondary sources have acquaired the dust from the atmosphere. Atmospheric dust settled, was trapped for a period of time, or may have been eroded, transported by runoff and/or wind and again deposited elsewhere. Hence, dust is a recycled material. Its quality and quantity at many sites are controlled by laws of erosion, deflation, transportation and deposition.

A.3 THE ASSOCIATION BETWEEN DUST, SOILS (OR DEPOSITS) AND LANDFORMS IN DESERT TERRAINS.

Three major factors govern geomorphic processes that shape the landscape, the evolution of landforms and the development of aridic soils in deserts:

Table A.1: Physiographic Units, Landforms and Associated Soils/Surficial Deposits

	Landform	Landform Component	Relief Type	Source/Parent Material	Climate	Soil Type; Type of Surficial Deposit
Plain, Piedmo..	**Loess Plain**		Plain	Loess	Semi-arid to Moderately Arid	Loess, Loessial Soil
	Playa, Sabkha		Plain		Arid to Extremely Arid	
		Center		Fine Alluvium		Takyr Soil, Solonchak Soil
		Transition Zone		Sandy to Fine Alluvium		Solonchak Soil,Takyr Soil
		Margin		Gravelly to Sandy Alluvium		Reg Soil, Solonchak Soil
	Sand Dune		Hill, Plain	Sand		
	a. Stabilized Dune			Semi Arid to Arid	Sandy Regosol	
	b. Active Dune			Arid to Extremely	Eolian Sand Arid	
Plain, Piedmont, Plateau	Terrace					
	a. Alluvial Terrace	Terrace Tread	Plain	Coarse Alluvium	Arid to Extremely Arid	Reg Soil
				Loess	Semi-arid to Moderately Arid	Loess, Loessial Soil
				Sand	Semi-arid to Extremely Arid	Alluvial Sand, Sandy Regosol
	b. Alluvial Fan Terrace	Terrace Tread	Plain	Coarse Alluvium	Arid to Extremely Arid	Reg Soil, Gravelly Regosol (on sieve deposits)
	c. Transition: Talus-Alluvial Terrace		Hill, Plain	Coarse Colluvium/ Alluvium	Arid to Extremely Arid	Reg Soil, Gravelly Regosol
	d. Ballena		Hill, Plain	Coarse Alluvium	Arid to Extremely Arid	Coarse Desert Alluvium, Incipient Reg Soil
	e. Rockcut Terrace	Terrace Tread	Plain	Hard/Soft Bedrock	Arid to Extremely Arid	Hammada, Lithosol
	Fan					
	a. Alluvial Fan		Plain	Coarse Alluvium	Arid to Extremely Arid	Coarse Desert Alluvium, Incipient Reg Soil
				Coarse and/or Fine Alluvium	Arid to Extremely Arid	e.g., Brown Alluvial Soil, Alluvial Gley
	b. Debris Flow Fan		Plain	Debris Flow Deposits	Moderately Arid to Extremely Arid	Debris Flow Deposit, Sieve Deposit, Gravelly Regosol
	Active Channel and/or Floodplain		Plain	Coarse and/or Fine Alluvium	Semi-arid to Extremely Arid	Gravel, Sand, Silt, Clay, in Varying Proportions: Coarse Desert Alluvium, Alluvial Sand, Loess, Incipient Reg Soil
Hillslope, Escarpment	**Plateau**	Crest	Plain, Hill	Hard, Brittle Bedrock Extremely Arid	Semi-arid to	Hammada Soil, Lithosol
		Flat Divide	Plain	Hard, Brittle Bedrock	Semi-arid to Extremely Arid	Hammada Soil, Lithosol
		Saddle	Hill	Hard Brittle or Soft, Erodible Rocks	Semi-arid to Extremely Arid	Lithosol, Loessial Serozem, Serozem, Hammada Soil
	Undulating Hills		Hill	Soft, Erodible Rocks, Loess, Sand	Semi-arid to Extremely Arid	Loessial Soil, Dune Sand, Alluvial Sand, Sandy Regosol, Lithosol, Serozem Soil
	Badlands		Hill	Soft Erodible Bedrock, (loess, shale, marl, chalk)	Semi-arid to Extremely Arid	Lithosol, Regosol, Loess
	Rocky Hillslope		Mountain, Hill	Hard, Brittle Bedrock	Semi-arid to Extremely Arid	Lithosol (not continuous, often in patches)
			Mountain, Hill	Soft, Erodible, Friable Bedrock	Semi-arid to Extremely Arid	Lithosol, Regosol, (often in patches)
	Colluvial Hillslope	Footslope	Mountain, Hill	Hard, Brittle and/or Soft Erodible Rocks	Semi-arid to Extremely Arid	Loessial Serozem, Lithosol
	Talus Hillslope		Mountain, Hill		Moderately Arid to Extremely Arid	
	a. Debris Flow Talus			Debris Flow Deposits		Gravelly Regosol, Reg Soil
	b. Sieve Deposit Talus			Sieve Deposits		Gravelly Regosol, Reg Soil
	c. Rockfall Talus			Rockfall Deposits		Gravelly Regosol, Reg Soil

Notes on Table A.1: Physiographic Units, Landforms and Associated Soils/Surficial Deposits.

The table relates soil types and surficial deposits to the various landscape features (physiografic units or landforms) that are widespread in deserts (Table E.2.1 characterizes soils by their dust attributes and some other properties, such as gravel and salt content).

The subdivision of landscape selected here enables the user to separate landscape features according to two categories:

1. Landforms that have a clear signature on regularly used visual aids.
2. Landforms that carry soils that may be easily identified and are different from each other.

All of the widespread desert landforms are included. The general order of the landforms in the table reflects the abundance of dust in the soil and to a certain degree takes into account the frequency of occurrence of the landforms in desert terrains. Since we could closely examine Mid-Eastern soil only in the Negev and the Sinai, the data reflect desert terrain in these regions; they are, however, very similar to other desert terrains in the Middle East.

Relief types are subdivided into three groups:

1. Mountains: relief > 200m; gradients > 20°.
2. Hills: relief of 20-200m; gradients > 15°.
3. Plains: relief < 20m; gradients usually < 10°.

Source and parent materials of different hardness, weatherability and erodibility may determine soil nature. Hard, durable rocks, such as dolomite, flint, syenite and diorite, usually weather into gravel, which harbours dust and salts from external sources (windborne and washed-in by water). Soft, friable rocks such as shales, chalks, sandstones and mudstones weather down to sand and finer fractions, mixed with external dust and salts.

The climate in hot arid environments is here subdivided into four regimes, according to mean annual precipitation:

1. Semi-arid - 250-400 mm/year;
2. Moderately arid - 150-250 mm/year;
3. Arid - 80-150 mm/year;
4. Extremely arid - < 80 mm/year.

1. **Lithology** - rock composition, texture and structure. This factor largely affects the mode and rate of weathering, the type of weathering products, the roughness at the surface, the susceptibility of the debris mantle to erosion by runoff and wind, the porosity and permeability at and near the surface. Soil properties and soil development at any particular site in deserts are strongly influenced by the type of bedrock or surficial debris mantle. The original composition, texture or structure of the parent material are to be observed in desert soil for very long periods of time.

2. **Climate** manifests its influence on desert landforms and soils mainly through precipitation and wind. Rainfall amount, duration and intensity determine water availabilty and thereby control the processes of runoff, erosion, mass movements and deposition. Water infiltration controls the penetration of dust into the soil profile as well as introduction of salts, precipitated upon evaporation. Atmospheric circulation and wind introduce most of the airborne dust and salts into a given site. Settling dust, dissolved salts, infiltration and runoff determine the nature of the soil.

3. **Topography** or the physiogrphic nature of the landscape. Factors such as gradient, aspect and surficial roughness are included here. The processes that shape and maintain both the landforms and the soils are largely affected by topography. Especially significant are the

condition of a landform - degradation, stability or aggradation. On a stable surface the rate of soil formation and maturation is usually the most rapid.

As emphasised in chapter A.2 dust in most desert terrains is a secondary, allochtonous material. The accretion of dust in the soil is a function of the flux rate of dust import and settlement as well as the condition of the potential receptacle — the type of debris mantle, the stability of the surface, the mode and rate of penetration, etc.

The interaction between the landform and the climatic elements is best reflected in the desert soil. The genetic relationship between soils and landforms on the one hand and lithology, structure, gross physiography and climate on the other hand, enable us to subdivide the landscape on the basis of these later major controlling factors. Table A.1 presents a list of the most frequently encountered desert landforms. These are also readily identified on airphotos and may be interpreted from large scale topographic maps. Twelve major types of landforms are recognized; further subdivision leads to a total of twenty types (plates 1–9). The soils related to these landforms are listed in the last column of table A.1. Certain soil types are unique to particular landforms whereas others are characteristic to a group of landforms. For definitions of these landforms and soils the reader is referred to the glossary in Appendix G.4.

A.4 DESERT SOILS AND SURFICIAL DEPOSITS — CLASSIFICATION AND DESCRIPTION.

In order to be able to estimate or predict the properties of desert soils or deposits in areas which are inaccessible, and to use available tools such as maps, airphotos, and climatic data, it is necessary to resort to a classification based on gross landscape features. A soil classification founded on parent material, landform and climate is largely genetic in nature. Such a genetic soil classification was chosen for the present report. It has been in use in Israel for the last three decades (Dan et al, 1962; Dan et al, 1972; Dan et al 1979). This soil classification includes the following soil orders and soil types (only the material pertraining to desert terrains is presented here):

1. Climatogenic soils: Serozem soils, Reg soils.

2. Lithogenic soils: Ḫammada soils, Lithosols, Regosols.

3. Fluviogenic and eolian soils: coarse desert alluvium, alluvial sand, eolian sand, loess, loessial soils.

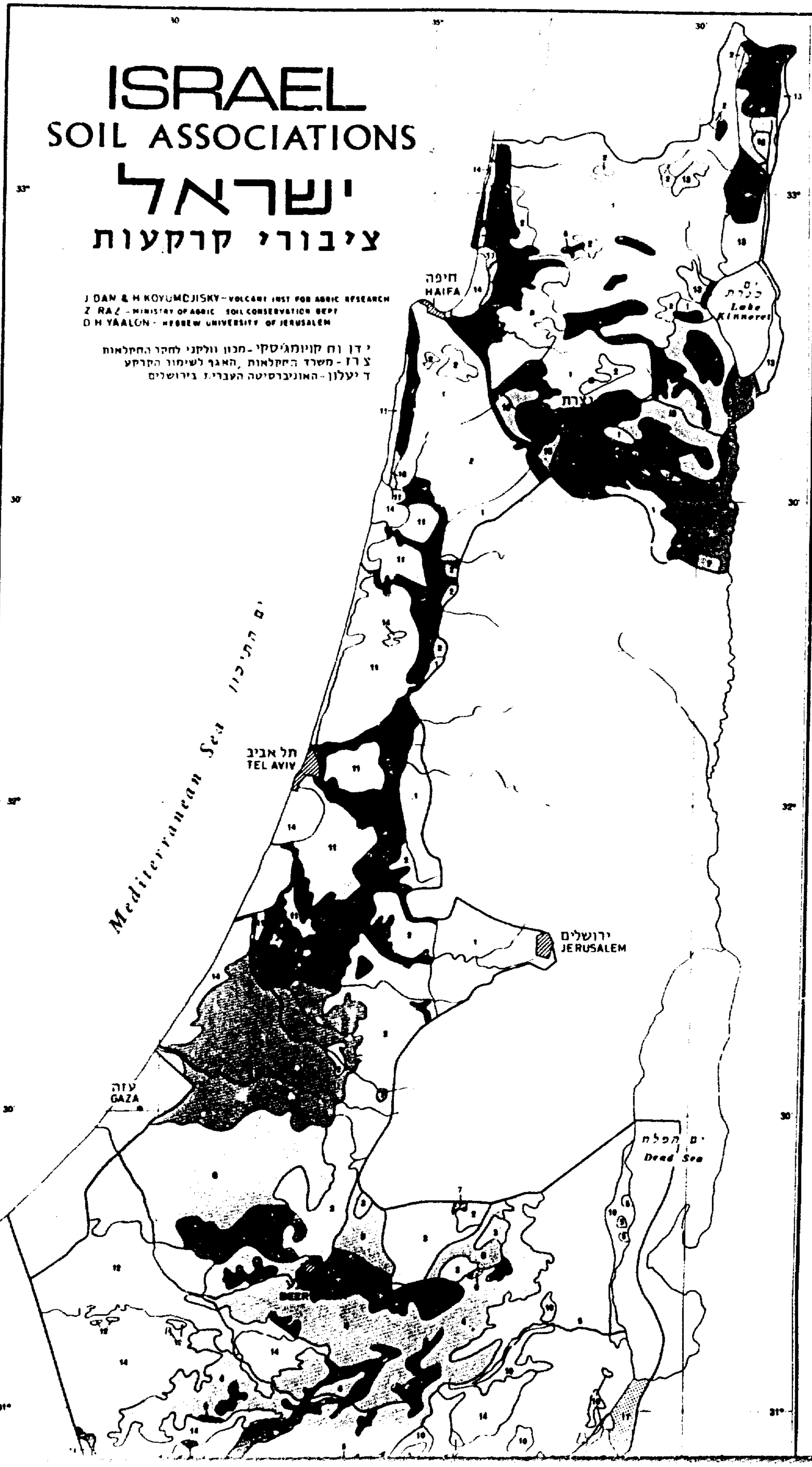
4. Hydrogenic soils: Takyr soils, Solonchak soils.

These are the soil types frequently encountered in hot-desert terrains. They are typical to the Negev, Sinai and similar Mid-Eastern deserts.

The following is a brief characterization of the more widespread soil types (for additional information see a Glossary in Appendix G.4):

Loessial Soils (aridic)

These are relatively thick (40-200 cm) soils, usually of loam, silt-loam or silt-clay-loam composition, developed on primary eolian or reworked loess. They are usually found in the semi-arid to moderately arid fringes of Mid-Eastern and other deserts, or areas which were under such climatic conditions in the past. Buried or exposed paleosols in loessial sections are



ISRAEL
SOIL ASSOCIATIONS
ישראל
ציבורי קרקעות
J DAN & H KOYUMDJISKY - VOLCANI INST FOR AGRIC RESEARCH
Z RAZ - MINISTRY OF AGRIC SOIL CONSERVATION DEPT
D H YAALON - HEBREW UNIVERSITY OF JERUSALEM
י דן וח קויומג'יסקי - מכון וולקני לחקר החקלאות
צ רז - משרד החקלאות, האגף לשימור הקרקע
ד יעלון - האוניברסיטה העברית בירושלים
חיפה
HAIFA
ים כנרת
Lake Kinneret
נצרת
ים התיכון
Mediterranean Sea
תל אביב
TEL AVIV
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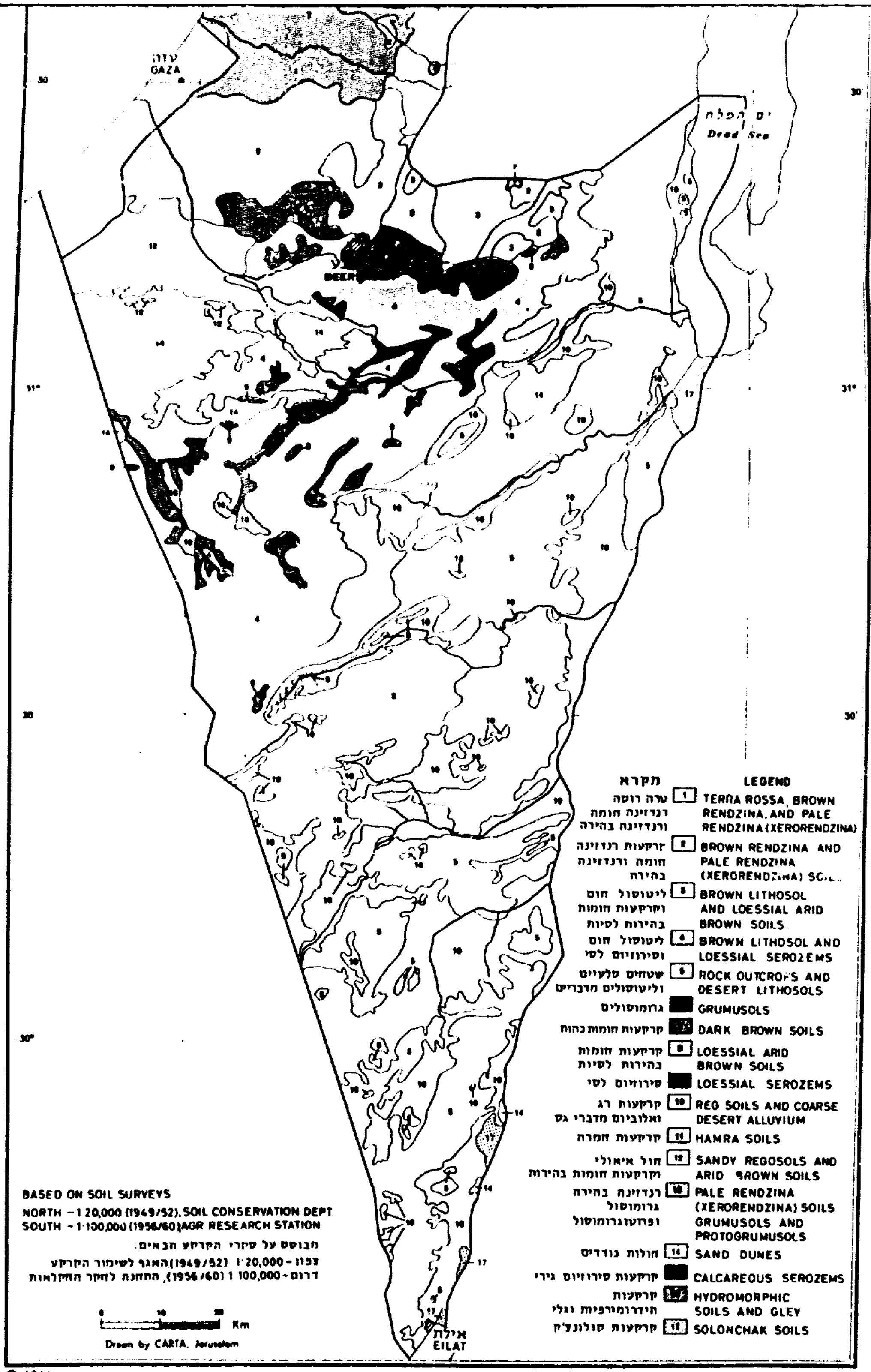
ים המלח
Dead Sea


עזה
GAZA
ים המלח
Dead Sea
BEER
30
31°
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LEGEND
1 טרה רוסה רנדזינה חומה ורנדזינה בהירה — TERRA ROSSA, BROWN RENDZINA, AND PALE RENDZINA (XERORENDZINA)
2 קרקעות רנדזינה חומה ורנדזינה בהירה — BROWN RENDZINA AND PALE RENDZINA (XERORENDZINA) SOILS
3 ליטוסול חום וקרקעות חומות בהירות לסיות — BROWN LITHOSOL AND LOESSIAL ARID BROWN SOILS
4 ליטוסול חום וסירוזיום לסי — BROWN LITHOSOL AND LOESSIAL SEROZEMS
5 שטחים סלעיים וליטוסולים מדבריים — ROCK OUTCROPS AND DESERT LITHOSOLS
גרומוסולים — GRUMUSOLS
קרקעות חומות כהות — DARK BROWN SOILS
8 קרקעות חומות בהירות לסיות — LOESSIAL ARID BROWN SOILS
סירוזיום לסי — LOESSIAL SEROZEMS
10 קרקעות רג ואלוביום מדברי גס — REG SOILS AND COARSE DESERT ALLUVIUM
11 קרקעות חמרה — HAMRA SOILS
12 חול איאולי וקרקעות חומות בהירות — SANDY REGOSOLS AND ARID BROWN SOILS
13 רנדזינה בהירה גרומוסול ופרוטוגרומוסול — PALE RENDZINA (XERORENDZINA) SOILS GRUMUSOLS AND PROTOGRUMUSOLS
14 חולות נודדים — SAND DUNES
קרקעות סירוזיום גירי — CALCAREOUS SEROZEMS
קרקעות הידרומורפיות וגלי — HYDROMORPHIC SOILS AND GLEY
17 קרקעות סולונצ'ק — SOLONCHAK SOILS
BASED ON SOIL SURVEYS
NORTH – 1 20,000 (1949/52). SOIL CONSERVATION DEPT.
SOUTH – 1:100,000 (1956/60) AGR RESEARCH STATION
מבוסס על סקרי הקרקע הבאים:
צפון - 1:20,000 (1949/52) האגף לשימור הקרקע
דרום - 1 100,000 (1956/60), התחנה לחקר החקלאות
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Drawn by CARTA, Jerusalem
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2

occasionally more clayey in nature. Aridic loessial soils often contain pedogenic $CaCO_3$ in nodules and may contain low concentrations of gypsum and/or salts. The soil is usually covered by a thin (1-3 mm) loess crust, usually denser and more cohesive than the underlying A horizon. The typical landscape of loessial terrains is flat, undulating or badland, with relief usually $\leq$ 20m (Plate 9A). The natural vegetation is a grass-steppe type. Under desert conditions shallow and saline gypsic Serosem soils develop, often containing some gravel.

Takyr Soils

Takyr soils are relatively thick (40-180 cm), of clay-loam or silt-clay-loam composition, and develop at the center of playas. These soils carry low to moderate amounts of gypsum and salts. The average thickness of the major soil horizons is: A — 7 cm, B — 18 cm, C — 50 cm. The soil develops on fine grained fluvial and eolian sediments deposited at the center of playas. It is usually gravel-free. The terrain is flat and is occasionally inundated by flood water. The soil may remain moist for several months a year. Usually there is a thin loess crust overlying the A horizon and the surface is poor in vegetation or sterile.

Solonchak Soils

Solonchak soils are highly saline playa and sabkha soils. Usually they have poor or no pedogenic structure, since their properties are determined by both deposition of fluviatile and eolian sediments and precipitation of various salts by shallow ground water and inundating flood water. At the surface there are crusts rich in salts and gypsum. Highly concentrated salt and gypsum layers are found at depth. Sometimes the soil is composed of saline silt and/or clay, but in other cases the soil is coarse textured with an abundance of fine gravel and/or sand. Soil thickness varies from several tens of cm to more than a meter. The relief is flat with some undulations, usually less than 100 cm high. Moisture is usually found close to or at the surface.

Reg Soils

Reg soils are gravelly soils developed on surfaces composed of coarse alluvium, i.e. alluvial fans and alluvial terraces. Their thickness ranges between 30-40 cm in Holocene Reg soils to more than 100 cm in Reg soils on older (Pleistocene) alluvial surfaces. The typical soil profile consists of a surficial gravelly desert pavement, a vesicular horizon underlying it (0.5-7 cm thick), a gravel-free or gravel-poor B horizon ($\leq$25 cm) and a gravelly C horizon (usually $\leq$35 cm). There are certain cases in which the B and C horizons are thicker than indicated above. B and C horizons of old Reg soils contain large amounts of pedogenic gypsum, salts, and in many cases, $CaCO_3$. Well developed Reg surfaces are devoid of vegetation. The older the surface the smoother it is. Holocene surfaces retain their gravel bar and swale configuration and roughness (Plate 5B), wheras surfaces older than 50-70,000 years are veneered by a complete cover of mechanically weathered angular gravel of $\leq$10 cm in size, to form a smooth desert pavement (Plates 11A,B; 14A,B). Under such a pavement there is usually a gravel-free horizon composed primarily of dust, gypsum and salts.

Hammada Soils

Hammada soils are gravelly soils developed *in-situ* on bedrock, on flat or gently sloping terrains. The gravel is usually mixed with a fine earth fraction composed mainly of dust, from an airborne source; some fine material is formed by weathering of the local bedrock. The surficial appearance and the soil profiles is very diversified:

1. In terrains built of hard brittle bedrock there are usually blocks of exposed bedrock and pockets of soil in-between (Plate 14D). The soils range from gravel and fines with poorly defined horisons, to pockets of loess in shallow depressions.

2. On hard bedrock one may find old Hammada soils that resemble old Reg soils in most respects: a desert pavement of varying degree of evolution at the surface, a vesicular A_v horizon underlying the pavement gravel, a B horison of varying degree of dust accretion (sometimes gravel-free) and a highly gravelly C horison merging with the bedrock. Plate 11A illustrates a very well developed Hammada soil on a limestone plateau.

3. In terrains built of hard sandstone, one often finds sandstone gravel overlying sand or sandy loam as a typical Hammada soil (Plate 14 C).

Hammada soils are usually gypsic, saline or calcic.

Lithosols

Lithosols are shallow stony soils without very distinct horisons, on a weathered or a slightly weathered bedrock and usually they are saline. They are, then, similar in general appearance to some Hammada soils. However, the term lithosol usually applies to the soils that are found on hillslopes, generally over a soft bedrock such as chalk and marl. In these cases they are light in color. They are darker where they are developed on hard rocks, such as limestone.

Serosem Soils

Serosem soils are aridic soils (usually of grey, grey brown color) that have calcic, gypsic and/or saline horisons at shallow depths. Excluded are several soils which may have some similar characteristics, such as Reg and Hammada soils. Under the Serosem soil category one may find loessial Serosems, stony Serosems, and calcic Serosems. In all these soils the amounts of dust are high, often several tens of percents.

Sandy Soils

Sandy soils are soils which include sand as the major textural component. Such soils are rather diversified, according to the pedogenic processes involved. Hence, one may define sandy Solonchak soils, sandy Regosols, sandy loessial soils, calcic alluvial sands and others. The dust sized fraction in these soils may reach 10–30%.

Regosols

Regosols are poorly developed soils derived from unconsolidated parent materials (gravel, sand and loess). They are rather deep and are typical to hillslopes or badlands. In deserts there are several types of Regosols: gravelly Regosols, on sieve deposits and other unconsolidated gravelly slopes; sandy Regosols, in sandy terrains; and loessial Regosols on hillslopes in loessial terrains.

Alluvial Soils

Alluvial soils are usually soils that are fluvially derived from some other areas than where they have originally formed. Such soils are accumulations of soil material which has been eroded elsewhere. Within this category one also finds soils that have developed out of alluvial deposits: the structure or stratification of the alluvium is clearly visible in them, in spite of pedogenic horisonation.

A.5 THE FRAMEWORK OF THE REPORT.

The present report includes the following topics:

1. **Atmospheric Dust in Deserts — a Review.**

Since much of the dust in desert terrains is allochtonous — introduced into the deposits through the surface of the soil — it is of paramount interest to recognise the nature and characteristics of the dust in the atmosphere. Several subjects are emphasised here: mobilisation, transport and deposition; particle sise distribution; mineral composition.

2. **The Non-Gravelly Materials in Desert Soils and Deposits — Sand, Dust and Salts.**

The soil and deposits in deserts are composed of two fractional components — gravel and fine earth. Gravel, as related to dust, is treated briefly in part D of the report. Fine earth — sand, silt and clay — are of a major concern as the theme of this project. Texture — size distribution and composition — is described and analysed in chapter C.1. Textural feature of non-saline components, composed mainly of quarts, feldspars, calcite, dolomite and clays are presented and discussed. Some of these features are utilised and compared in the following chapters. The mineral composition is described and interpreted in chapter C.2.

Desert soils and deposits usually contain significant quantities of salts including chlorides, sulfates (mostly gypsum) or carbonates. These salts appear in the soil as dust-sised particles or aggregates, that also affect the consistency of the soil. Chapter C.3 deals with salts, their composition and distribution.

Most desert soils and some desert deposits are veneered by a distinct layer or crust, usually of greater consistency than underlying layers or horisons. Although the mechanical characteristics of these surficial covers has not been studied under the scope of the present report, some features that may be pertinent to the ease of dust release are described in chapter C.4: ground cover — types and occurrence.

3. **Gravel in Desert Soils and Deposits.**

Gravel constitutes a major component in many desert terrains. It is both a primary debris produced by weathering on hillslopes and plateaus, and a frequent fraction in fluvial deposits. Gravel serves as a major trap for settling airborne dust. Both gravel and dust combine to form a variety of dust-rich gravelly soils. Some comments on the relationships of gravel, dust and salts are presented in part D.

4. **A summary and Discussion** of dust in desert terrains is presented in part E. It includes the main issues presented in the former chapters, together with a general interpretation of the evolution of dust mantles in deserts. The broad quantitative trends are emphasised in part E: The rates of dust and salt accretion, the evolution of desert soils, the effects of changing climates and paleosols and a comparison between dust related properties in the terrains of the Negev and Sinai.

5. **References.**

Part F contains the references used in this report. Special attention should be given to the sources of information and soil data supplied by the articles and monographs on Israeli soils. Data concerning loessial soils, serosem soils and sandy soils were drawn from these sources.

6. Appendices.

Part G serves as a source of information and lays a foundation for parts B – E. Part G includes the appendices. Field and laboratory methods are described, and soil data and profiles are presented. A glossary serves for definition of the technical terms used in the report. The reader is encouraged to become acquainted with the appendices before using the report.

This report is accompanied by a procedure for the evaluation of dust potential in desert terrains. The methodology for dust evaluation is explained in the procedure, whereas the data on which it is based, their analysis and interpretation are presented in the report.

PART B ATMOSPHERIC DUST IN (AND FROM) DESERTS — A REVIEW

B.1 INTRODUCTION

Dust in the atmosphere is an important factor of a global scale. Its effects are far reaching; several are mentioned here:

1. **Climatic effects**: a partial screen for incoming and out going radiation and a nucleation agent for raindrop formation. Climatic changes may have been caused by dust in the atmosphere.
2. Dust is an important **bio-ecological factor**. Its existence and concentration may determine or effect the survival of certain faunal and floral species.
3. Dust is a major **sedimentary component**. It is one of the main contributors to both marine and continental deposits.
4. The effects of dust on **human ecology** may be profound. Its existence in the air determines visibility, effects the respiratory system, the eyes and the skin. The operation of various machines and instruments may be effected by dust of high concetration.

Deserts, where there is in many cases no protective cover such as vegetation or gravel, are especially prone to have a dusty atmosphere. Most of the mineral dust in the atmosphere is derived from deserts and carried all over the continents and the oceans by the global atmospheric circulation. The major dust contributor is the Sahara Desert; it yields beetwen a third and a half of the global desert dust.

The Middle East, containing a vast desert area and being close to the Sahara Desert and downwind of it, is signifcantly affected by desert dust. The following chapters emphasise examples from studies on the Sahara and the Middle East. Since much of the material and the interpretation in the present report are related to desert terrains in Israel and the Sinai, we present in Part B data on desert atmospheric dust in this area.

B.2 THE SOURCES OF DUST

There are two groups of sources to the atmospheric dust in deserts:

1. **Primary sources**: weathering products, volcanic ash, particles from biogenic origins, marine aerosols, cosmic dust and aerosols produced by man.
2. **Secondary sources**: Colluvial and alluvial deposits, desert soils. eolian sediments — sand and loess, lake and playa sediments.

All these sources combine to form a large reservoir of dust in deserts. Especially important are the secondary sources of alluvial sediments, soils and sediments of playas and dried lakes. Outcrops of shales, marls, chalks and sandstones contribute large amounts of dust upon weathering; such are vast areas in the northern Sahara, the southern Levant and the northern Arabian Desert.

Vast areas of weathered rocks, various surficial deposits and desert soils yield fine earth particles — sand and dust. Along the desert fringe, in moderately arid to semi-arid environments, there is a combination of the effect of man — grasing and often cultivation — and drought, to form a dust producing sone (fig.B.2.1). Man's activity in such a sensitive environment often and repeatedly leads to erosion, deflation and desertification.

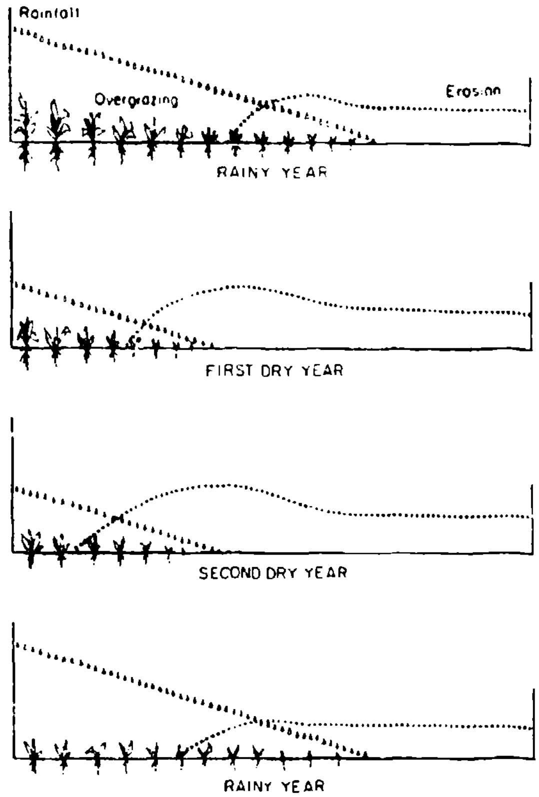


Figure B.2.1 Erosion and dust mobilisation following overgrasing (or aridisation). From Lundholm (1979).

The Sahara is a major source of desert dust. Several 10^8 tons of dust are lifted into the atmosphere and are transported towards the Atlantic Ocean and the eastern Mediterranean region. Ganor and Mamane (1981) quote large amounts of dust leaving the Sahara towards the west ($70 \cdot 10^6$ tons/yr) and the northeast (some $20 \cdot 10^6$ tons /yr). Jaenicke (1979) estimates about $260 \cdot 10^6$ tons/yr transported and deposited in the Atlantic Ocean. Figure B.2.2 illustrates some of these trends. Yaalon and Ganor (1979) have traced regional dust storms moving from Libya and Egypt to the southeastern Mediterranean and the Levant, as presented in figure B.2.3. Some of these storms are derived as cyclones from the western Mediterranean basin and their trajectories are deflected eastward and northeastward over the Western Desert. Other trajectories are those of the Sudano-Saharian depressions which cross the Sahara from south to north and are deflected to the east (Dubief, 1979; fig.B.2.4).

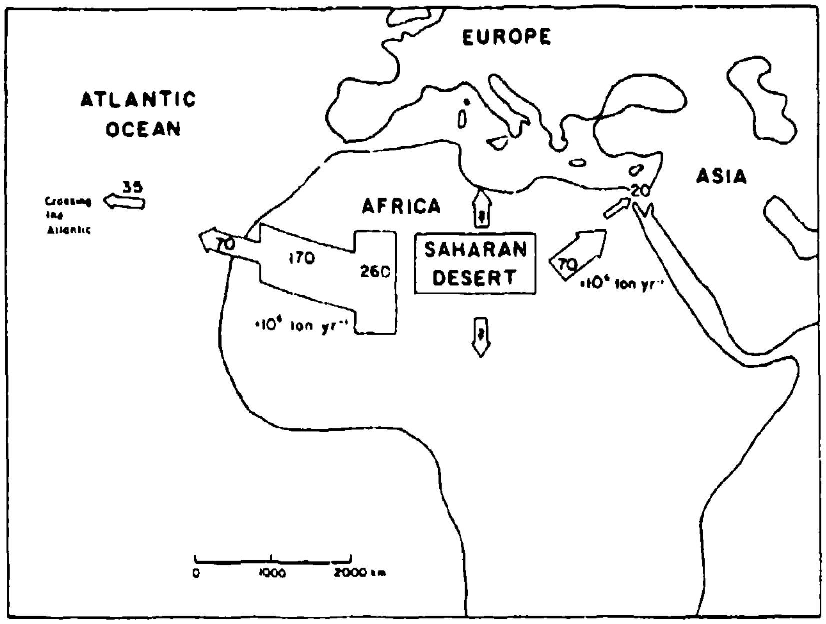


Figure B.2.2 A schematic diagram of the westward and eastward transport of Sahara dust (Ganor & Mamane, 1981).

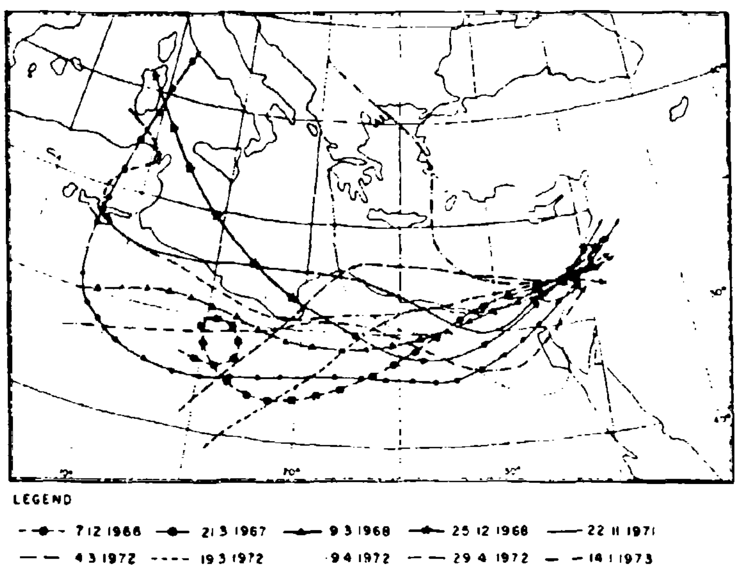


Figure B.2.3 Particle trajectories for selected regional dust storms showing the calculated east Mediterranean trajectories (Yaalon & Ganor, 1979).

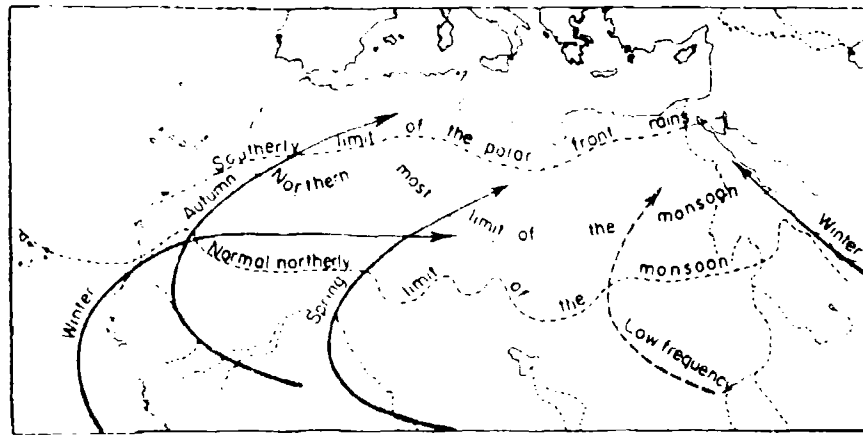


Figure B.2.4 Trajectories of Sudano-Saharian depressions and limits of the polar front and monsoon rains (Dubief, 1979).

Other prominent source areas of atmospheric dust are the Arabian Desert, the deserts of south central Asia, the Australian deserts, the Kalahari and the Namib Deserts and the deserts of western South and North America — Atacama, Sonora , Mojave and the Great Basin.

B.3 METEOROLOGICAL AND SYNOPTIC CONDITIONS

There are several main meteorological conditions for the raising of dust and the development of dust storms (Jackson et al.,1973; see also chapter B.6):

1. Strong heating of the ground.
2. Development of local and large scale convections and ascending trajectories.
3. Conditions producing cyclonic storms, related to strong upper-level jet streams. "Major dust storms are produced when the upper-level jet and the strong surface heating interact" (Jackson at al., 1973,p.139).
4. Increasing horizontal pressure gradients, which may lead to wind speeds of 30–35 knots or more with gusts of wind, related to local circulation.

All these bring about ascending currents and horizontal winds that mobilise and transport dust on local and regional scales. Dust may be lifted to elevations of several km and transported to distances of thousands of km from its source area (chapter B.6).

Many typical storms incorporate descent and heating of the air, which may lead to extreme drying of the ground, enhances surface temperature, increase evaporation from the surface, cause destabilization of the near-by atmosphere and further another major cyclonic development (Jackson at al.,1973).

An illustration of the synoptic situation during a typical dust storm is presented in figure B.3.1. Most of the dust storms in the Negev are associated with a passage of a frontal system from west to northeast. A depression along the Red Sea leads to the mobilisation and transport of dust from the south and the east (Katsenelson,1970; Ganor & Yaalon,1979). A dusty

atmosphere is often accompanied by a cold weather — a result of intrusion of cold air from the mid-latitudes to tropical areas across the Mediterranean basin (Kalu,1979).

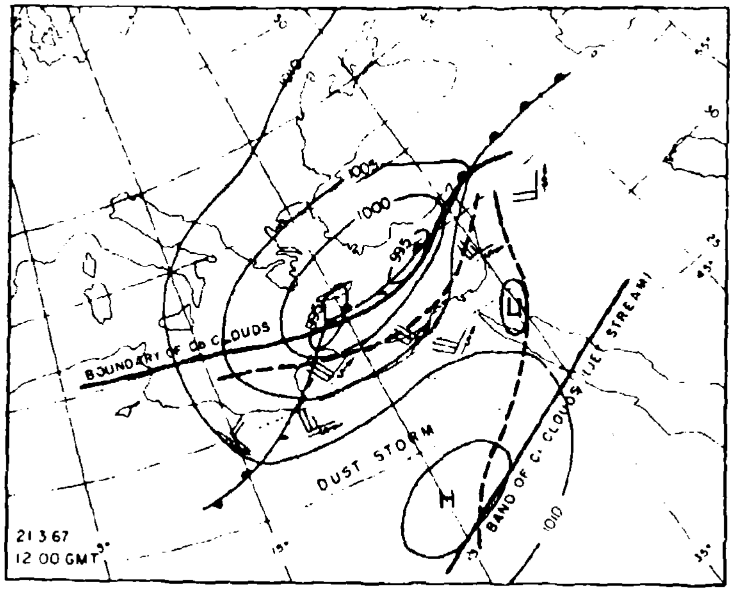


Figure B.3.1 Aereal extent of the march 21, 1979, dust storm, as traced from satellite photos, superimposed over the synoptic map (Yaalon &Ganor,1979).

Dubief (1979) enumerates the cyclones with which Saharan dust storms are associated, according to their origin:

1. Cyclones from the Mediterranean basin, along the northern coast of Africa.
2. Atlantic cyclones, associated with the polar front, that enter the Sahara through Moroco.
3. Subsidiary cyclones from southern Moroco which move through Libya and the eastern Mediterranean.
4. Tropical cyclones, moving along the Inter-Tropical Front in the Sudan region. Turbulent winds, which raise dust to high altitudes are related to the steep rise of the temperature, and are associated with the warm sector of the cyclones. Such winds in the southern Sahara develop also in the cold sectors; the turbulence here is enhanced by the orography, as is the case of the Tibesti Mountains. The hot winds intensify from the morning into the afternoon; the turbulence is of a thermal origin.

B.4 MOBILIZATION AND TRANSPORT OF DUST AND SOME WIND CHARACTERISTICS

Mobilization of Dust by Wind

The detachment of dust from a surface is determined by three sets of factors:

1. The conditions at the surface — soil factors: roughness, texture and cohesion. Particle sise and the content of fine dust, salts and water are controlling factors (Gillette,1981).

2.The topography and microtopography, such as relief, slope, aspect and vegetation, are factors which intimately interact with the wind and affects its aerodynamic characteristics at and near the ground.

3. The aerodynamic characteristics, such as wind speed and duration,tractive force or drag velocity, thermal features (effecting vertical flow components) and turbulence. Moisture in the air should also be considered, since it affects water absorption and settling of dust.

The relationships between these factors control the mobilisation of dust. For example, high critical velocities are required to mobilise particles larger than 0.2mm, due to their weight, but also for particles smaller than 0.06mm, because of their greater degree of cohesion (figs. B.4.1-2; Chepil, 1951; Gillette, 1981). It should also be noted that high wind velocities lead to mobilisation of unsorted materials whereas winds of relatively low velocity mobilise and transport a better sorted dust.

Generally, the greater the intensity or velocity of the wind, the larger is its power and force to mobilise and transport particulate material — sand and dust. Soil factors, such as surficial roughness, partiale sise and cohesion pose resistance to wind deflation and have to be considered in every case (Gillette, 1981). Wind velocities greater than 6 m/sec are usually required for the development of dust storms (Jackson et al., 1973; Péwé, 1981). However, surface conditions may render this threshold most variable (Shikula, 1981). Dust storms in the Negev are usually associated with wind velocities of 6-10 m/sec (Katsenelson, 1970). Only 12% of the winds measured in this region have velocities of more than 6 m/sec and barely 1% — velocities exceeding 10 m/sec (Yaalon and Ginsbourg, 1966).

Transport of Dust

Tracing the movement atmospheric dust is performed by employing various methods: space and aerial imagery, interpretation of synoptic maps, redioactive, isotopic and biogenic tracers, chemical and mineral components. It is still very difficult to calculate the amounts of transported dust even for dust storms whose courses are well recorded (see chapter B.8).

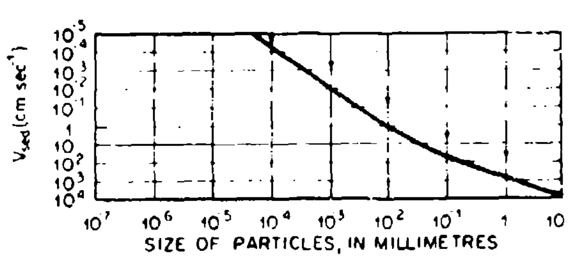


Figure B.4.1 Sedimentation velocity and size of particles (Gillette, 1981; partly after Bagnold, 1941).

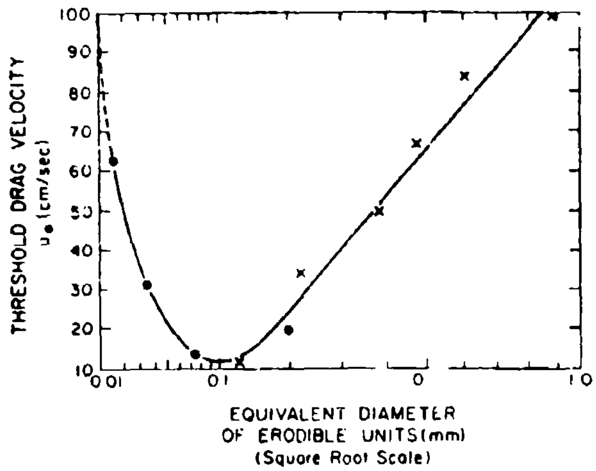


Figure B.4.2 Threshold friction velocity versus nondisperse particle size (from Gillette, 1981; after Chepil, 1951).

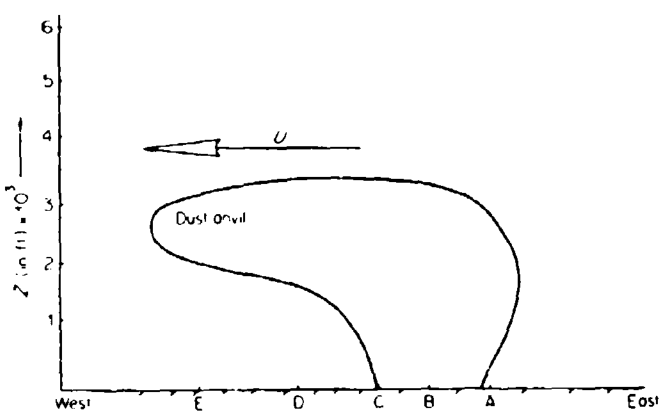


Figure B.4.3 Propagation of dusty atmosphere
A: Onset of clearance at station A
B: Station under dusty atmosphere
C: Dust front just reaching station C
D: Good visibility at night with a chance for
E: deterioration by mid-morning owing to turbulent mixing

(Kalu, 1979).

Dust storms in Israel are related to two main wind directions, according to particular synoptic conditions.

1. Dust storms associated with winds blowing from the west, southwest and northwest, accompanying cold fronts of cyclones moving from the west. Such a situation is frequent during the winter. The winds are intense and the dust is raised and transported on both local and regional scale (Katsenelson, 1970). An expression of the predominance of winds from the westerly sector is found in the direction of seif dunes in the Sinai and the Negev (Rosenan, 1953).

2. Dust from the Arabian Desert, carried by winds blowing from the southeast, east and northeast. Such a situation is frequent during the spring, the autumn and the winter; it is associated with the existence of a low pressure trough along the Red Sea, with an extension into the Gulf of Elat and the Negev, or a depression over North Africa, leading to pronounced easterly winds from the Arabian Desert into the Levant.

The rates of dust mobilisation and transport varies greatly. For example, there was a distinct difference between the dust input of the Sahara during the period 1958-63 and that of 1969-71; the former was a wet period whereas the latter a drought one (Morales, 1979). In terms of continuity, there is a special difference: there is a continous transport of fine dust from the Sahara westward; the transport to the northeast is rather intermitent (Morales, 1979; Schüts et al, 1981).

Several phases may illustrate the mobilisation — transport processe (Kalu, 1979; fig. B.4.3):

1. The mobilisation phase is usually related to a condition of atmospheric instability (see chapter B.3). This initial phase is associated with vertical drafts in the source area; it may be termed the instantaneous phase.

2. The transport phase begins mainly as the vertical turbulance brings the dust to layers of fast wind motion - the spreading phase. Only fine dust reaches this level; coarser particles have settled in the previous phase.

3. An equilibrium phase is the most stable. The transport is under the influence of the prevailing winds. It occurs at distances of tens to hundreds of km downwind.

B.5 DUST STORMS -- FREQUENCY AND DURATION

The frequency of dust storms varies from one region to another. The number of dust storms in Egypt and southern Israel is similar — 10 storms/yr, on the average (Yaalon & Ginsbourg, 1966; Yaalon & Ganor, 1979). West Africa experiences an average of 20 dust storms/yr and some regions in China — 30 dust storms/yr. Mexico City has some 60 dust storms/yr, on the average (Péwé, 1981).

Dust storms usually continue from 1 hour to several days. Many local storms which develop during a particular day are sustained by local convectional winds for 1–3 days. The aerosols may remain in the atmosphere for 5–30 days (Jackson et al., 1973).

There is a marked seasonality in the frequency of dust storms. In the Be'er Sheva area (northern Negev) there is a high frequency of dust storms during the spring (March-April), a medium to low frequency during the winter (December-January) and practically no storms during the height of summer (July-August; Katsenelson, 1970).

The number of "dusty" days may change drastically along a transect from the desert into the more humid region. Figure B.5.1 illustrates this point: 40–150 "dusty" days in the Negev and the Sinai and less than 10 such days in northern Israel.

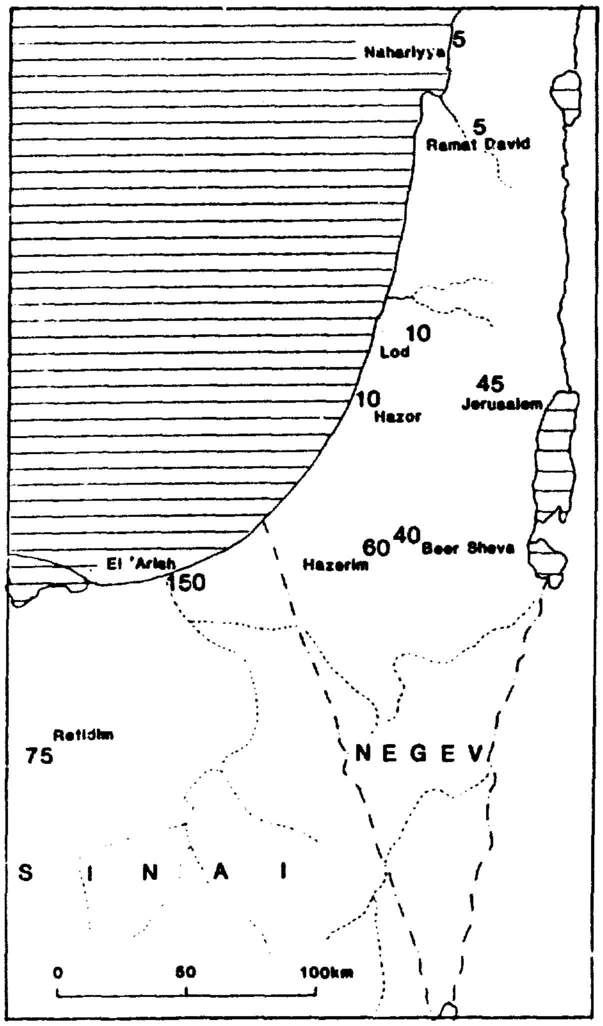


Figure B.5.1 The frequency of days of dust storms from the Sinai and the Negev to northern Israel. Annual average — 1967/68 — 1970/71 (modified from Ganor & Yaalon, 1979).

B.6 THE DISTRIBUTION OF DUST WITH ALTITUDE AND DISTANCE FROM THE SOURCE AREA

The distribution of dust in the atmosphere is usually very uneven, both spatially and temporally. It is dependent on factors such as synoptic conditions, elevation above the ground, distance from the source area. For example, dust storms that develop in the eastern Mediterranean region during the passage of a cold front have a rather high concenration of dust, which decreases rapidly after the passage of the front (Ganor & Mamane, 1981).

Several typical situations of dust distribution were characterised by Ganor & Yaalon (1979):

1. Dust is carried in an unstable atmosphere. A good dispersion of dust to heights of -4000m. As the atmosphere stabilises and the turbulence subsides, dust settles in a dry state.

2. Dust is carries in an unstable atmosphere and stays in the air for several days. The portion that does not settle is well dispersed in the air to heights of several 10^3m and is carried from the Sahara to the northeast with unstable air masses.

3. Dust is carried in an unstable atmosphere. In the south — dust storms; in the north — precipitation. Dust is dispersed in the air to heights of 2000m and is washed down by rain in the later region.

4. Stable air at high elevation limits the upward dispersion of dust to the top of the cloud layer. Dust is washed down by precipitation.

Dust may be barred from upward dispersion by a stable layer at a certain elevation above the ground. Most of the dust is highly concentrated in low layers of the atmosphere. Such a condition is frequently observed in Israel. The dust concentration is usually 2000-4000μm/m^3 near the ground and $\leq 500\mu g/m^3$ at elevation of 1,500m. At higher elevations, above the mixing zone, the concentration is very low —-10$\mu g/m^3$ (Ganor & Mamane, 1981).

Examination of the concentration of dust with both elevation above the ground and the distance from the western Saharan source area yields the following general scheme (fig. B.6.1; Schütz et al., 1981):

1. Approximately two-thirds of the total mass falls within the first 1,000 km.

2. High concentration of both submicron and larger particles are typical to elevations of 1-4 km above the ground, close to source area. At distances $\geq$300 km from the coast much of the dust is of a submicron size. It is concentrated mostly at heights of 1-5 km above the Atlantic Ocean and its vertical distribution remains unchanged for distances of several 10^3 km.

3. The general distribution of dust (both submicron and >0.001 mm in size) is nearly even throughout much of the atmosphere (to altitudes of 5 km), at distances $\geq$1000 km from the west Saharan source area.

The general pattern, then, is that for long distances (800-1000 km) there is a high concentration of dust in the zone of the greater wind velocity (the 900 mb zone; Kalu, 1979). Only at greater distances, after much of the coarse particles have settled, there is a rather even concentration of dust with altitude.

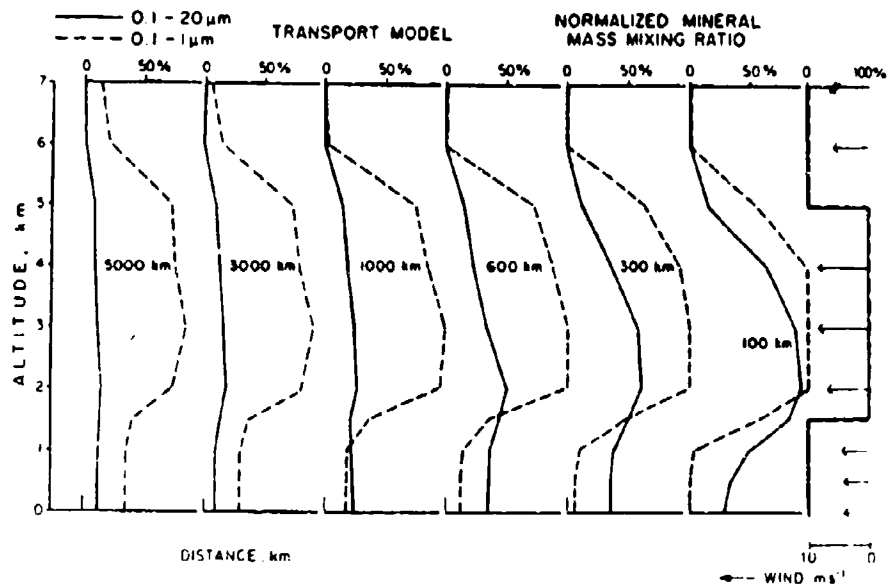


Figure B.6.1 Vertical distribution of mineral dust with altitude and distance from the Saharan dust source, across the Atlantic Ocean (Schüts et la., 1981).

B.7 SOME RELATIONS OF ATMOSPHERIC DUST TO CLIMATE

The amounts and particle sise composition of dust are related to climate in several ways. Some pertinent factors are:

1. The mode and degree of weathering and the nature of the weathering products.
2. The mode and rate of removal, transport, sorting and deposition of debris.
3. The soil forming processes and the nature of the soil.
4. The water budget and the type of vegetation.
5. The nature of the atmospheric conditions – temperature, air humidity, wind, precipitation.

In regions of subhumid and humid climates there is an extensive formation of dust-sised materials by weathering and soil forming processes. However, three factors render most of this dust unavailable to deflation and transport by winds: the vegetation, the high content of fine silt and clay and the moisture — both in the ground and in the air. Surficial dust in non-arid regions is

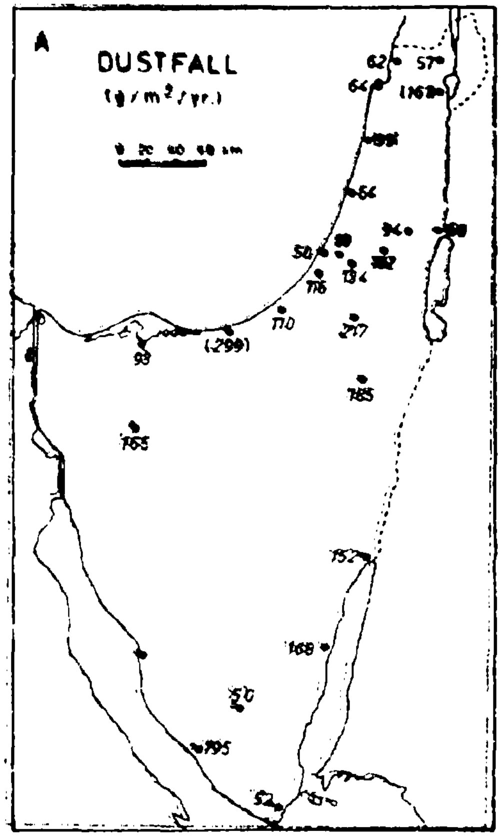
protected and cohesive. Most of the atmospheric dust is derived from the arid terrains. On the other hand, the non-arid environments serve as the best surficial traps for settling dust.

Generally, there is a decrease in the frequency and duration of dust storms from the arid zone into the subhumid and humid regions (see also chapter B.5). The main reason for this situation is the desert being a region of exposed dust whereas in the more humid regions there is hardly a possibility of a local dust storm. Also, most (and in some cases — all) the dust that originates in the deserts settles near the source area or along the desert fringe. Rather low amounts of dust reach the humid regions, but as stated above — the dust is trapped there for long periods of time.

Figure B.7.1 illustrates the variation in the amounts of dustfall in the Sinai and Israel (Ganor, 1975). Dustfall in the Sinai and the Negev is 2–3 times greater than in northern Israel. Particle size also decreases from south (desert) to north (subhumid) in this region. The content of fine silt and clay in the atmospheric dust increases from south to north: In Beer Sheva (-200 mm/yr of mean annual precipitation) there is 10–30% clay in the settling dust, whereas in Jerusalem and Haifa (500–600mm/yr) there is a clay content of 30–50% and 45–70%, respectively (Yaalon & Ginsbourg, 1966). Figure B.7.2 illustrates these finds. This trend is found also in the soils of the respective regions.

The effects of climatic change on the amounts of atmospheric dust are considered to be profound. During the glacial periods of the Pleistocene there was a large supply of dust from glacial regions and a high rate of loess deposition around the glaciated areas. This atmospheric dust, reinforced by occasional emission of volcanic ash, may have led to further cooling of the atmosphere, air subsidence in the subtropics and aridisation in this later region (Bryson & Baerreis, 1967; Jackson et al., 1973). Isdo (1981), however, emphasises the possibility of heating of the atmosphere due to the "thermal blanketing" by airborne dust. The production of dust from glacial, volcanic and desert sources may have been up to 10^2 times greater during extended periods of the Quaternary than at present (Jackson et al., 1973).

Some of the sequences of buried loessial paleosols in areas like the northern Negev (Bruins, 1976) may reflect changes in the rates of incoming and settling dust rather than "local" climatic changes. In such a situation, variation in the characteristics of these paleosols — the content of secondary carbonate and clay — reflects climatic fluctuations in the major source areas, such as the Sahara.



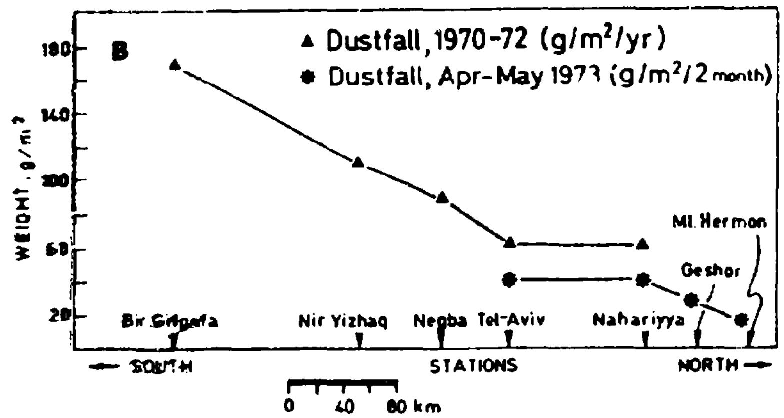


Figure B.7.1 A. Annual dustfall, average for the period 1970–1973 (Ganor, 1975).
B. The change of settling dust along a transect from the south to the north in the Sinai and Israel (Ganor, 1975).

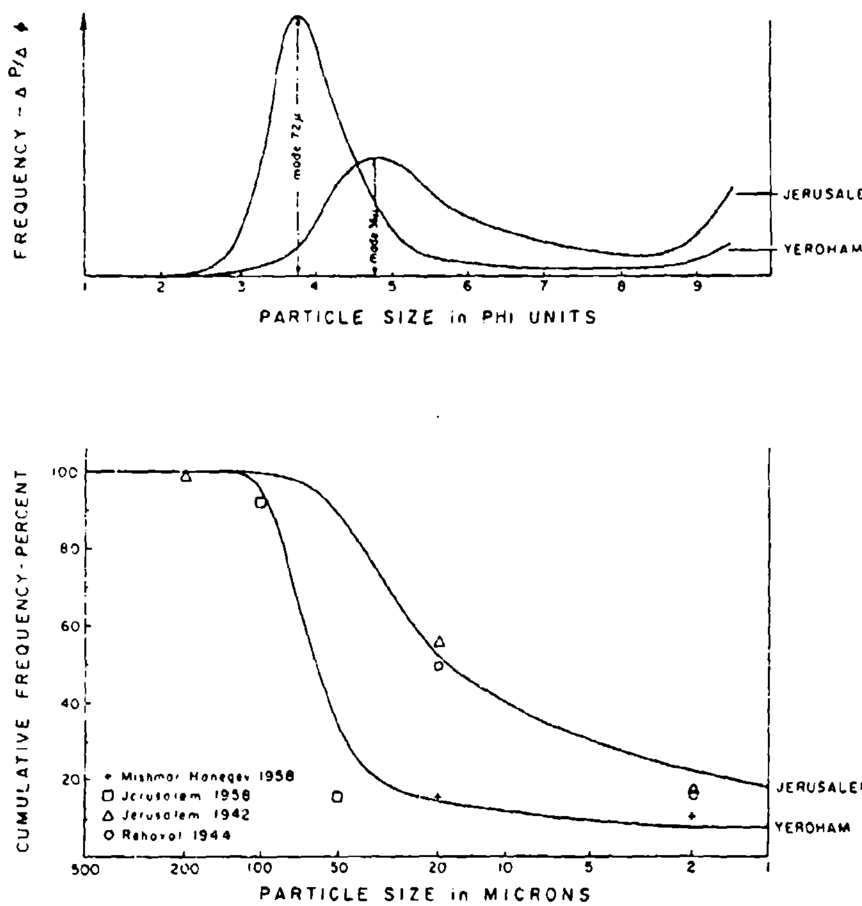


Figure B.7.2 Grain-size distribution of dust samples from Israel. Curves are for samples collected in Yeroham and Jerusalem during storms of November 1958. Additional data from Mishmar Hanegev, Jerusalem and Rehovot are marked by symbols and taken from published accounts (RAVIKOVITCH, 1953; KAPLAN, 1959; SLATKINE, 1960). From Yaalon & Ginzbourg (1966).

B.8 AMOUNTS AND CONCENTRATIONS OF DUST IN THE ATMOSPHERE (see also chapter B.6).

The concentration of dust in the atmosphere varies greatly with time and space. In arid regions one may find very high concentration — from 23,000μg/m^3 in a dust storm in the Negev (Ganor & Yaalon, 1979) to extreme concentrations of 176,000μ/m^3 elsewhere (Orgill and Sehmel, 1976). Concentrations over the oceans are much lower — from a fraction of a μg/m^3 over a quiet ocean to 100μg/m^3 over a stormy one (Péwé, 1981). The average figures are usually rather low even for areas where the terrains are dust-rich and the availability of dust is high: 1. 10–140μg/m^3 in the Great Plains (Prospero, 1982); 2. 100–300μg/m^3 in Be'er Sheva or 130–500μg/m^3 in Elat (Ganor, 1975). $\leq$10μg/m^3 is frequently measured during bright days and 1000μg/m^3 — during hasy days. Figure B.8.1 illustrates the average dust concentrations on a broad regional scale.

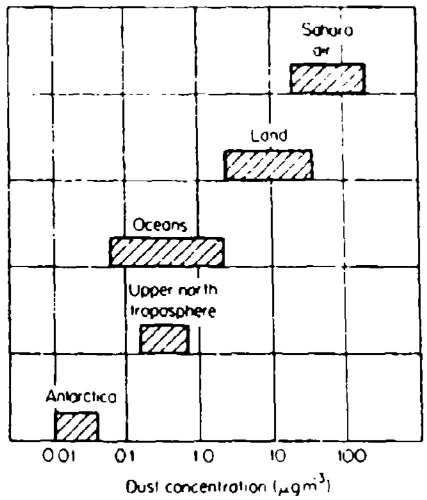


Figure B.8.1 Survey of the concentration ranges of mineral dust in the troposphere based on numerous studies by among others – the following authors: Blifford, Chesselet, Duce, Ferguson, Hoffman, Gillette, Goldberg, Griffin, Jaenicke, Prospero, Rahn, Schütz, Winchester, Zoller (Junge, 1979).

The quantities of dust contributed annually to the atmosphere is estimated to be about $500 \cdot 10^6$ tons/yr. Between 1/2 and 2/3 of this amount is raised from the Sahara Desert — about $260 \cdot 10^6$ tons/yr from the western Sahara (Schütz et al., 1981) and some $70 \cdot 10^6$ tons/yr from the eastern Sahara (Ganor & Mamane, 1981; fig. B.2.2). It is possible that $150\text{–}200 \cdot 10^6$ tons/yr of net weight leave the Sahara; most of it is carried westward and appreciable amounts are transported to the northeast and the north. Most of the dust which leaves the Sahara is deposited in the first 10^3 km (Schütz et al., 1981); most of the sediments in the eastern Atlantic Ocean off the Saharan coast and the soils northeast of the Sahara are derived from this dust fallout. A single dust storm may bring to the eastern Mediterranean basin more than 10^6 tons of dust. Frequent dust storms in the Negev may deposit 2–10g/m^2 per storm; 50–10g/m^2 of dust may be added to the ground during a major storm. Most of the dust in this region settles in the winter-spring — February-May. (see chapter E.2 for additional data).

B.9 PARTICLE SIZE DISTRIBUTION

The particle size distribution of atmospheric dust is determined by four major factors: The size distribution of the material available on the ground for the mobilisation and transport by the winds; the characteristics of the mobilising and carrying wind — its tractive force, velocity profile, direction and turbulance; the distance from the source area; the climatic regime along the course of the dust motion — temperature, air humidity, precipitation of various kinds.

Sorting and differentiation of eolian sediments and airborne mineral particles are active along the entire route. Figures B.9.1 and B.9.2 demostrate the decrease in particale sise of wind blown materials from the Saharan source area to the Atlantic Ocean: sand fields (ergs); sandstorms carring sand and silt; loam and silt-loam transported as loess; silt and clay carried as atmospheric dust to great distances. Figures B.7.2 and B.9.3 shows further differentiation as the dust moves from an arid sone into a subhumid one.

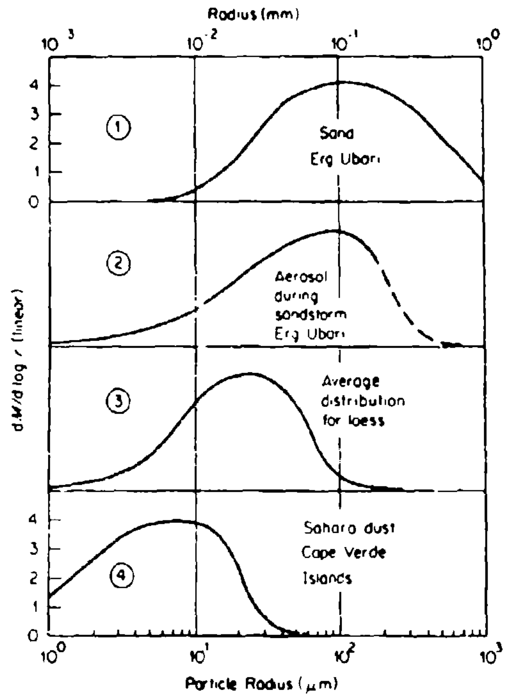


Figure B.9.1 Comparison of different idealized mass distributions based on the following sources:

(1) Schutz and Jaenicke (1974), sand from the Libyan desert, Erg Ubari
(2) Same source and location as (1) but aerosol during sand storm
(3) Füchtbauer and Müller (1970), average of 8 loess distributions from various continents

(4) Jaenicke and Schutz (1977), average mass distribution over the Cape Verde Islands

(Junge, 1979).

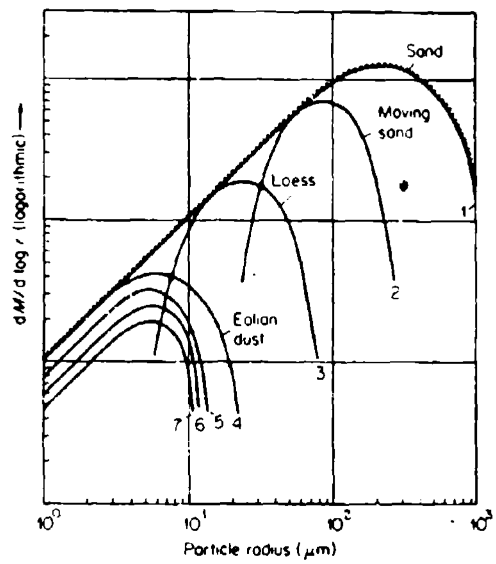


Figure B.9.2 Sand fractionation processes by wind, schematic. The original sand distribution is fractionated into major fraction 2, 3, and 4 as a function of distance from the source. Curves 5, 6, and 7 depict the change in concentration due to both wet and dry removal from the atmosphere. The sum of curve 2, 3, and 4 should be equal to the original curve 1

(Junge, 1979).

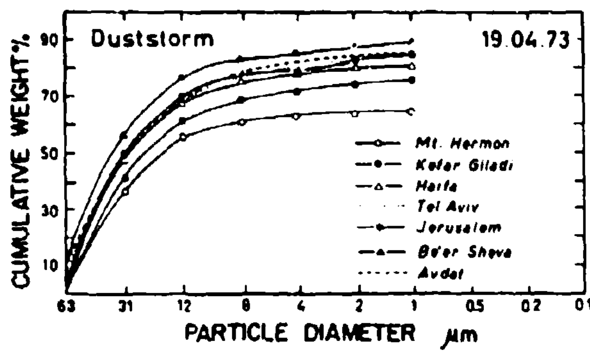


Figure B.9.3 Cumulative grain size curves for dust collected during the storm of April 19, 1973. Note the decreasing coarse silt content going from the desertic South (Avdat, Beer Sheva) to the Mediterranean North (Kefar Gileadi, Mt. Hermon)
From Yaalon & Ganor (1979).

Frequently, the dust in the atmosphere over deserts and adjacent areas is composed mainly of coarse and medium sized silt. Several examples will illustrate this point:

1. Ganor (1975) summerised the particle size characteristics of settling atmospheric dust in regional dust storms in Israel: (a) Fine sand — 2-7%; coarse and medium sized silt — 20-45%; fine silt — 5-10%; clay — 14-20%. (b) There is a trend of the finer dust to be carried farther north. Figure B.9.1 illustrates this tendency for a particular storm.(c) Suspended dust is generally smaller in grain size than settling dust. The former includes a very high content of fine silt and clay. This dust was collected at high elevation above the ground and during bright days. More than 80% is smaller than 0.002 mm in size. The maximal sizes measured were 0.015-0.020 mm.

2. Dust samples collected in Arizona are composed mostly of silt (-80%) with secondary fine sand and clay, -10% each (Péwé,1981). In figure B.9.4 we can see that dust samples in other regions, such as Kansas and Germany are similar in size but may contain less clay. Dust samples from Barbados, West Indies, are much finer — they are composed mostly of very fine silt and clay (see also chapter B.6).

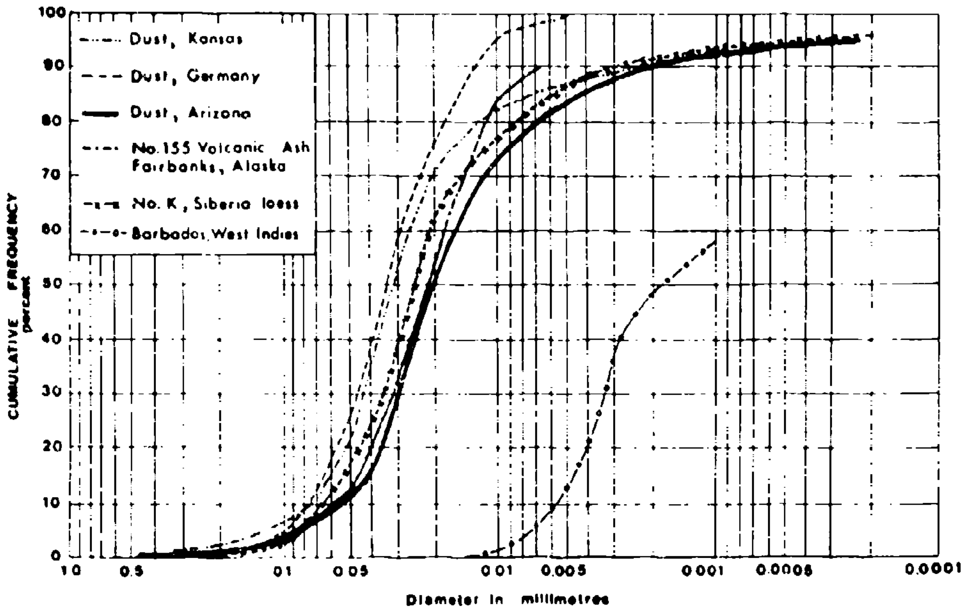


Figure B.9.4 Comparison of cumulative-frequency curves of the two major grain-size groups of desert dust. Curves on the left represent analyses of samples of common windblown dust of dust devils, haboobs, and other storms and of loess and volcanic ash. Such material is carried a few kilometres to less than 100 km. The curve on the right is of analyses of desert dust from the Sahara depsited in Barbados, West Indies. This is tropospherically sorted dust that moves as an aerosol and travels thousands of kilometres. Alaska, Siberia, and Arizona samples collected by Troy L. Péwé and analyzed at the Centre for Geomorphology, CNRS, Caen, France. Curves on the left from Péwé and others (this volume). Curve on the right is compiled from Prospero and others (1970).

From Péwé (1981).

B.10 MINERAL COMPOSITION AND MICROMORPHOLOGY

The minerological composition of atmospheric dust is determined by various factors, such as the lithology in the source areas, the differential size and density of the available particles and the characteristics of the atmospheric circulation and winds. Most of the desert dust in the atmosphere is derived from weathered surficial deposits and aridic soils. Much of the dust has been recycled many times so that its relationship to a particular source is somewhat obscured.

As emphasised in chapter B.9, much of the dust in deserts is silt with lesser amounts of clay. In the eastern Mediterranean region, where most of the dust is derived from the Sahara, the silt is composed predominantly of calcite (35-45%), quartz (30-40%), dolomite (10-20%) and feldspar (<10%). Soluble minerals, such as salts and gypsum compose less than 1%. The clays are predominantly montmorillonite (30-40%), with secondary kaolinite (15-30%) and illite (15-30%). Figures B.10.1 and B.10.2 present the composition of dust samples collected in Israel (Ganor & Mamane, 1981). The average content of the dust in Israel is: calcite and dolomite — 45%, quartz — 30%, feldspar and other silicate minerals — 7%, halite and gypsum — <1%, montmorillonite — ≤6%, Kaolinite — 3-6%, illite — 3-6%.

The above composition reflects the predominant contribution of dust from Cretateous and Tertiary carbonate rocks and sandstones of Paleozoic and early Cretaceous ages, as well as the surficial deposits derived from them — all in the northern Sahara and the deserts of the Middle East. The contribution from outcrops of igneous rocks is rather limited.

In the western Sahara one finds a slightly different composition: quartz is a major mineral in the silt fraction and illite — in the clay fraction. In southwestern United States there is usually a predominance of silicate minerals in the desert dust — quartz, feldspar, heavy minerals and clays — contributed by the vast exposures of igneous and metamorphic silicate rocks and their weathering products. The contribution of primary carbonate minerals is usually insignificant.

The micromorphology of the particles composing the silt fraction in the atmospheric dust in the Negev is as follows (Ganor, 1975):

1. Fine silt (<0.020 mm) shows good sphericity and roundness.
2. Larger silt particles are angular and less spherical.
3. Clay particles adhere to larger particles to form aggregates.
4. Particles of quartz and feldspar are usually weathered and broken. The latter are also pitted. Calcite particles are made of whole crystals, broken crystals and foraminifera (usually well rounded). Dolomite crystals are well preserved. Dark and heavy minerals are usually weathered, subangular to angular in form.

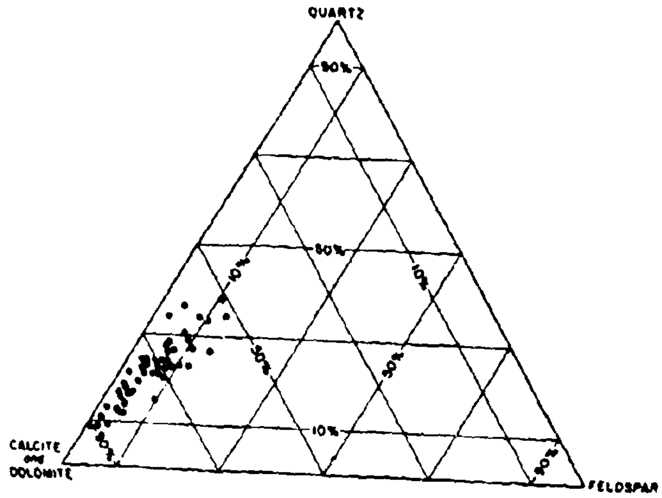


Figure B.10.1 The weighted percentage of dominant minerals found in the silt fraction of desert particles collected in Jerusalem during 55 dust storms (Ganor & Mamane, 1981).

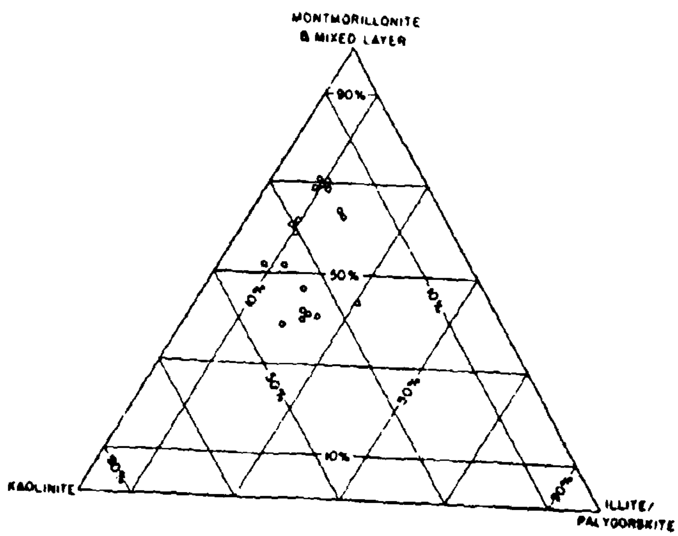


Figure B.10.2 The weighted percentages of clay minerals in the clay fraction collected during 19 dust storms. Note the low percentage of illite (Ganor & Mamane, 1981).

PART C THE NON-GRAVELLY MATERIALS IN DESERT SOILS AND DEPOSITS — SAND, SILT AND CLAY

C.1 TEXTURE — PARTICLE SIZE COMPOSITION AND DISTRIBUTION OF SAND AND DUST

Introduction

Particle size distribution of non-gravelly materials in the debris mantle and soils in deserts is determined by several main factors:

1. The influence of rock type on size distribution of the weathered mantle at a given site. Most rock types are hard and indurated and do not contribute to the sand and dust fractions in large amounts at the site of weathering. Thus one does not find a large content of fine particles derived from native limestone, dolomite, flint, granite, diorite and other types of indurated brittle rocks at a given site of weathering. On the other hand, large quantities of fine grained debris may be found on chalks, shales, mudstones and sandstones. Such debris may be transported by running water and wind to various sites of accumulation.

2. Particle size distribution of settling atmospheric dust. Such dust is of varying particle size, according to synoptic conditions, wind characteristics and sources of dust (see Part B). In some cases, the contribution from sandy sources renders the average dust texture rather coarse grained.

3. Selective trapping of dust fractions, after the dust brought to a site by wind or running water settles on the ground (see chapter E.2).

4. Differential mobility and translocation of dust fractions according to dust trap characteristics, hydrologic regime and water or soil salinity. Such differential mobility and accumulation are typical of slow dust accumulation, where the trapped dust and accompanying salts themselves gradually change the characteristics of the soil as a dust trap (see chapter E.2).

5. Climate, which determines to a high degree the course and rate of weathering of large particles to small ones, or the translocation of fine dust from surficial soil horizons into lower ones. Hence, under less arid climates or an environmental regime where coarser soil particles weather down to fine silts and clays,one should expect fine grained dust in areas further away from sources of sand, where eolian dust is dominant.

Dust Trapped In Archaeological Sites

Archaeological sites may serve as good long-term dust collectors. In the Negev there are many hundreds of archaeological structures of different ages which vary in size and proportion. Many of these structures were originally without roofs or their roofs had collapsed rather early after their abandonment. Most of the structures were filled with trapped dust during the first 1-2 millennia after their abandonment (see chapter E.2).

Four archaeological sites were sampled for particle size distribution: Tel Arad in the northwestern Negev, Be'er Resissim in the western Negev, the Sha'ar Ramon Fort in the central Negev and a building in Biqat Uvda in the southern Negev. The finest grained dust was found in Tel Arad, the site farthest from sources of sand and under the leasts arid climate. Particle size composition is silt(60%) $\gg$ sand(21%) > clay(19%). The average for all samples is silt(46%) > sand(36%) $\gg$ clay(15%). The finer fractions (silt + clay) are rather similar to those

...settling atmospheric dust (Ganor, 1975) in which coarse silt (0.016–0.063mm) comprises ...% of the silt + clay fractions. Fine sand (0.063–0.250mm) is dominant within the sand fraction (68% on the average) and may reach 90%, as in the Uvda Valley or be as low as 50%, as in the Sha'ar Ramon Fort.

...sial Soils And Loessial Serosems

Since loessial soils and loessial serosems are derived primarilly from eolian and reworked fluvial loess, they are composed mostly (60–95%) of silt and clay, but particle size is different in ... soils. Well developed loess soils are composed of silty-clay and silty-clay-loam. ... soils are formed in sites situated away from sources of eolian sand, under semi-arid to ... arid climates. Young, less developed loess soils under the same environmental conditions are usually silt-loam in nature (fig. C.1.1A). The loessial Serozem soils are sometimes silt loam and silty-clay-loam, as in the central Negev. Coarse silt is dominant in the silt fraction and clay content is significnt in areas where bare rock is exposed above pockets of loessial Serozam soils (Arzi, 1981). Usually, loessial soils turn into less clayey, more coarse grained soils under two sets of environmental conditions: (a) the close proximity of sources of sand, as in the western Negev, and (b) prevalence of arid conditions, as in the central Negev.

The dominant fractions in the loessial soils are fine sand, coarse silt and fine clay (fig. C.1.1B). Fine silt and fine clay are prominent in the B horizon of the loessial soils. In recent loess soils, such as in the upper member of the Netivot section of Paleosols (Bruins, 1976) one finds an average composition of silt (62%) ≫ clay (28%) ≫ sand (10%). The quantities of coarse silt and fine silt + clay in the dust fraction of soils are similar to those in settling atmospheric dust (Ganor, 1975). Older, buried paleosols are often more clayey in nature with clay (40–60% <=> silt (40–50%) ≫ sand (2–12%).The textural composition appears to have changed according to climatic cyclicity during the upper Quarternary (Bruins, 1976).

Takyr And Solonchak Soils

Playas — developed in the centrer of closed basins in arid environments — are characterized by two types of soils: (a) Takyr — a fine textured soil of slight to moderate salinity; (b) Solonchak — a soil of high salinity and diversified texture (typical also to Sabkhas — coastal saline flats). the texture and salinity of the respective soils are associated with the hydrological and sedimentological regimes of the sites in question: sorting and fining of sediment toward the center of playas and the position of the water table; a shallow water table leads to high salinity. Hence, there is a general zonation in particle size and salinity from the margin of playas toward their center (plate 3).

Takyr Soils

There is a difference in the textural composition of young Takyr soils and well-developed ones (figures C.1.1B; C.1.2d,e,f). The former are silt-loam whereas the latter are mostly silty-clay and silty-clay-loam. On the average, A horizons are of the silt (46%) > clay (41%) ≫ sand (13%) type. B horizons are of the clay (58%) > silt (42%) ≫ sand (21%) type, and C horizons are of the silt (55%) > clay (33%) ≫ sand (16%) type. The sand is usually fine sand. There is also a textural trend in the silty fractions of the different horizons: the A horizon — fine silt (27%) > coarse silt (19%); the B horizon — fine silt (33%) ≫ coarse silt (9%); the C horizon – coarse silt (39%) ≫ fine silt (16%). The clay is mostly fine clay; it is mostly prominent in B horizon (46% fine clay; 12% coarse clay).

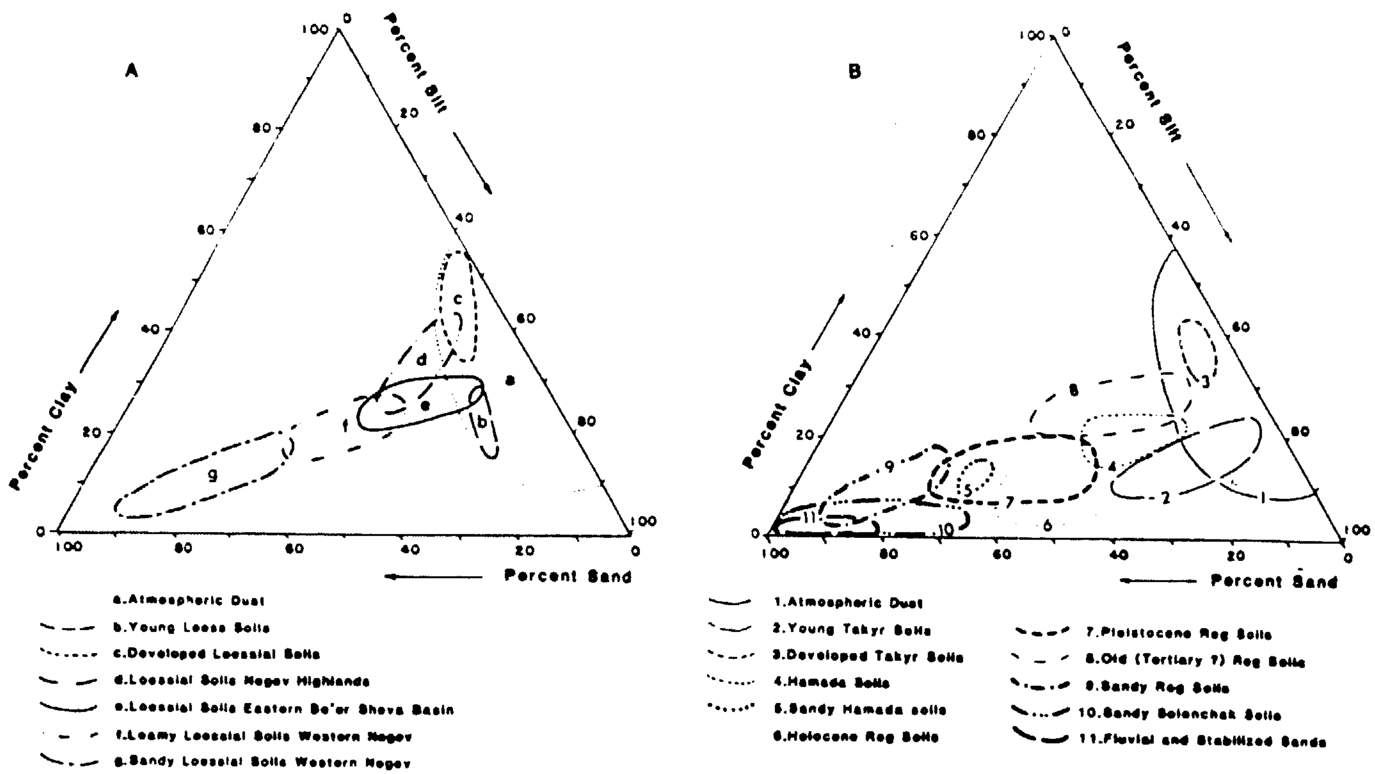


Figure C.1.1. A. The general textural composition of loess and loessial soils in the semi-arid to arid parts of Israel (the northern and northwestern Negev) see Fig. 1C for textural definitions.

B. The general textural composition of soils in the desert environments in Israel and the Sinai Peninsula (see fig. 1C for textural definitions).

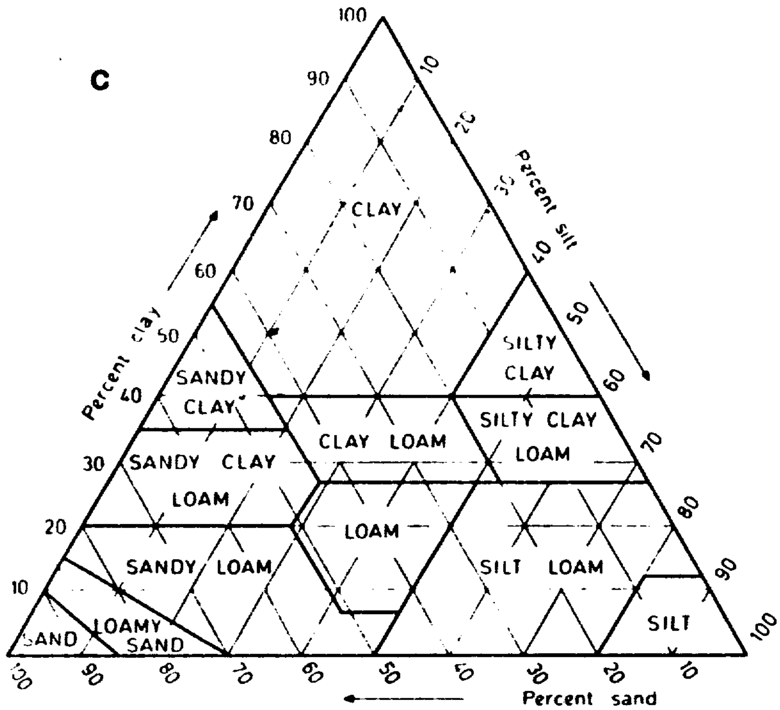


Figure C.1.1, Continued **C. Textural definitions of soils.**

There are some textural differences between Takyr soils in playa center and those located at playa margins; the material becomes finer as one approaches the center of the playa (fig. C.1.3A).

Takyr soils, then, are fairly similar in particle size to loessial soils, both in texture and in horizonation. This is understandable since the parent material is dust and the fine fractions are concentrated in the center of a playa; this leads to a continuous accumulation of silts and clays in a temporarily wet environment. Examination of fig. C.1.1B shows the similarity of Takyr soils (2,3) to settling atmospheric dust (1). Well developed Takyr soils are of a clay-loam texture — characteristic of average atmospheric dust in deserts.

Solonchak Soils

Solonchak soils are very saline. We deal here only with both non-gravelly and non-saline particulate materials in these soils.

The texture of Solonchak soils is highly dependent on their location within a playa or a sabkha, and on the differentiation of the incoming fluviatile load across the playa zones. For example, most of the Solonchak soils in the southern Arava Valley and along the Gulf of Elat are composed of sands, loamy-sands and sandy-loams. Sand is a substantial component of these soils which are composed of 30–70% sand, 10–20% silt and 1–10% clay (figures C.1.3B; C.1.2g-i). However, at the center of many playas one finds soils of finer texture; for example silty and sandy clays at the center of the Yotvata Playa in the southern Arava Valley (Amiel and Friedman, 1971) or silty-clay-loam Solonchaks of the Sedom Sabkha, south of the Dead Sea (Dan, 1981). Only the textures of the soils at the center of the playas may be predicted, having a predominance of silt and clay (as in Takyr soils): silt (50–60%) > clay (20–45%) > sand (1–24%) in the Sedom Sabkha.

Usually the upper horizons are of coarser texture than the lower ones. The profile is more of an accumulating nature than that of a soil divided into clear genetic horizons.

Recent Alluvium And Colluvium

Recent alluvium is most diversified with respect to particle size distribution. It may include gravel, sand and finer fractions in various proportions (see part D). Only under a few environmental conditions may we expect clear trends such as exhibited by loessial, sandy (including friable sandstone) and shaly terrains, where the particle size of the parent material highly affects the size distribution of the resulting debris.

In gravelly alluvial channels which drain terrains built of hard brittle rocks that do not weather to fine fractions, we find varying amounts of sand and silt with a very small component of clay. These fractions usually do not amount to more than 20% of the surficial alluvium and in most cases their content ranges between 1 and 10%.

The non-gravelly fractions in coarse desert alluvium are usually sandy-loam in nature: sand (80–90%) $\gg$ silt (10–15%) $\gg$ clay (1–5%). At the surface (0–10 cm in depth) there is a higher concentration of fine fractions than at depth. An example is the alluvial channel of Wadi Mandara (eastern Sinai). At 0–10cm depth the sediment consists of 87% sand, 11% silt and 2% clay. At 10–60 cm depth there is 96% sand, 4% silt and only traces of clay.

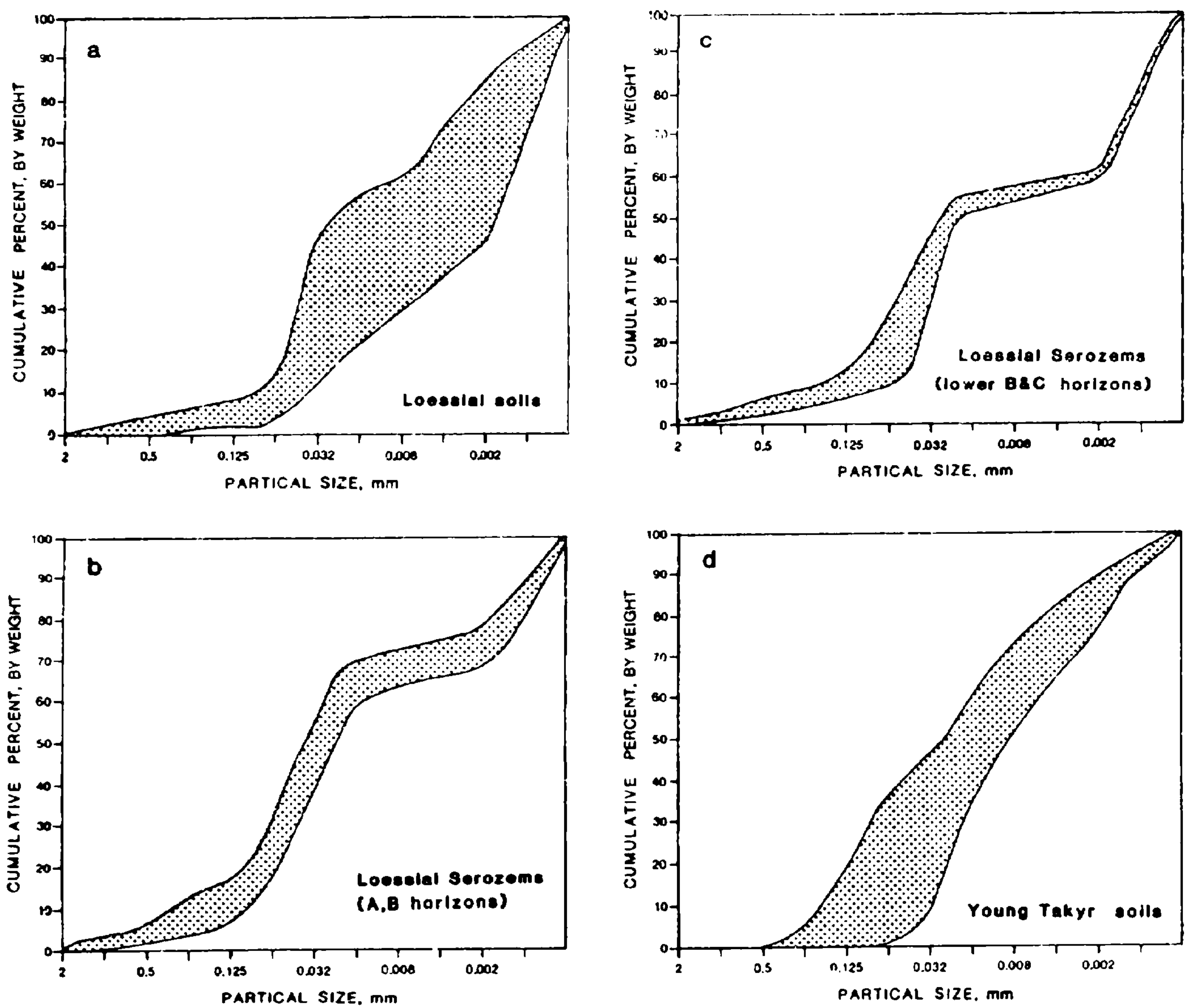


Figure C.1.2. Partical size distributions in aridic soils in Israel and Sinai. The ranges of the frequently encountered distributions are presented.

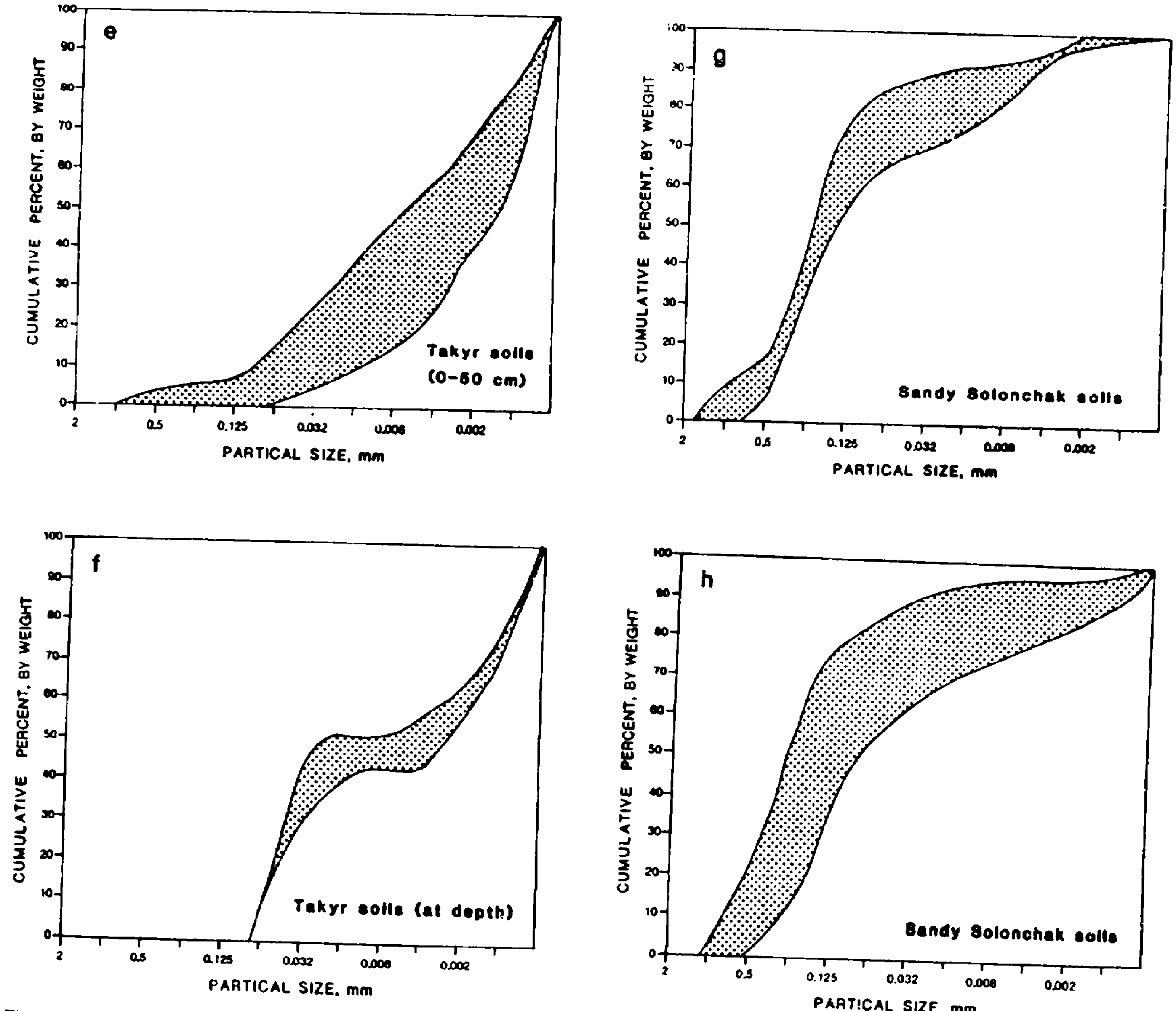
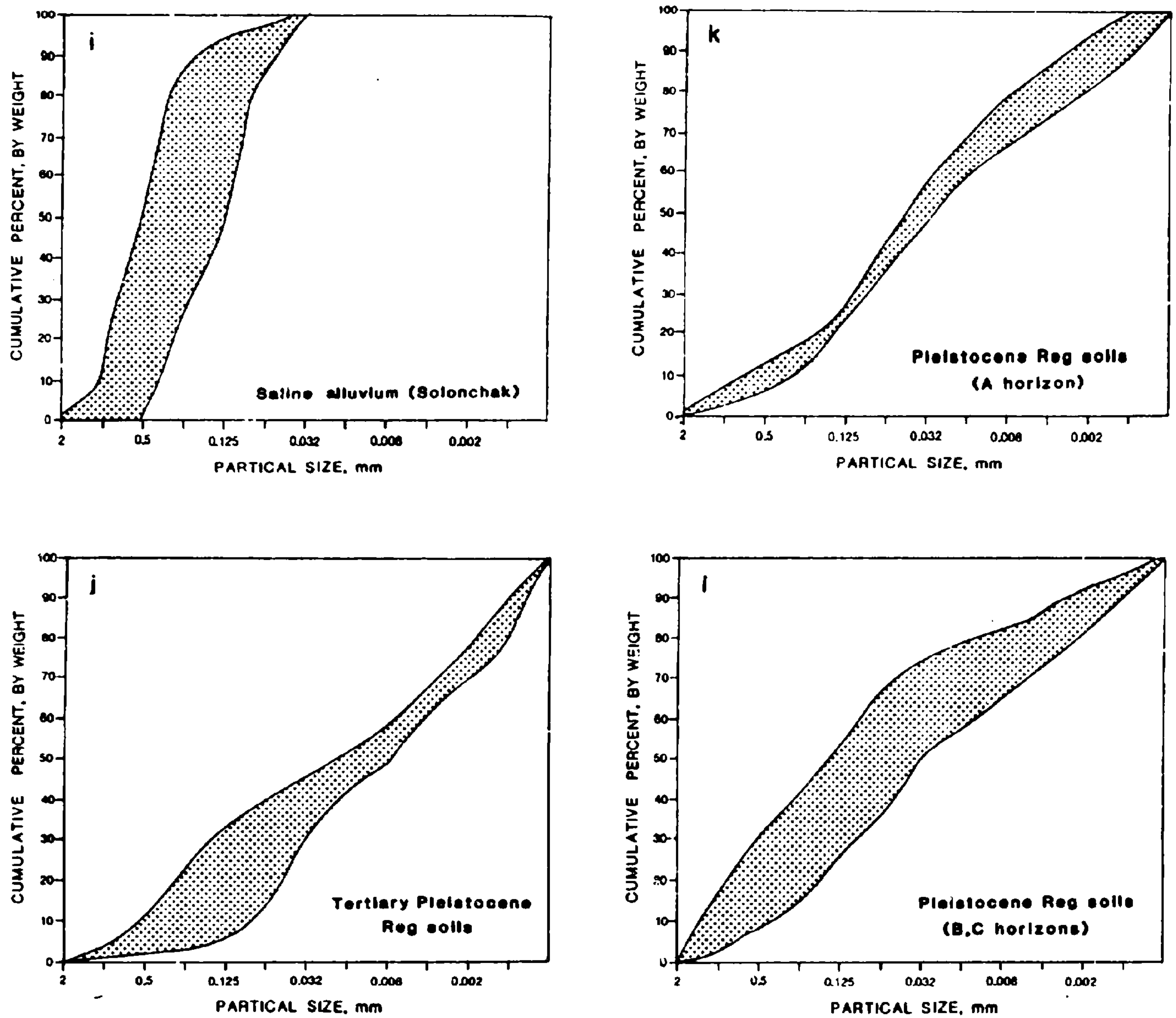


Figure C.1.2, Continued



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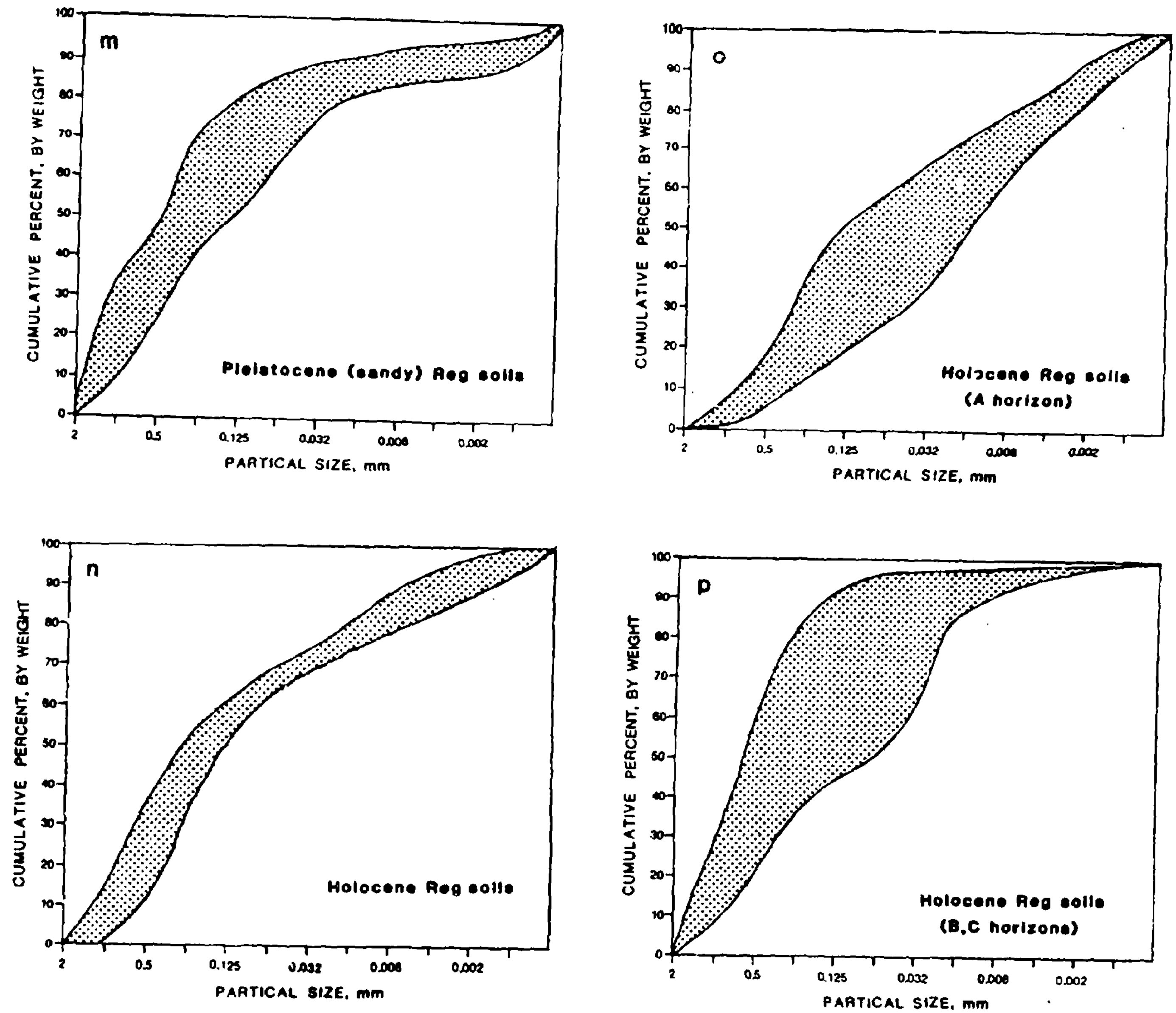

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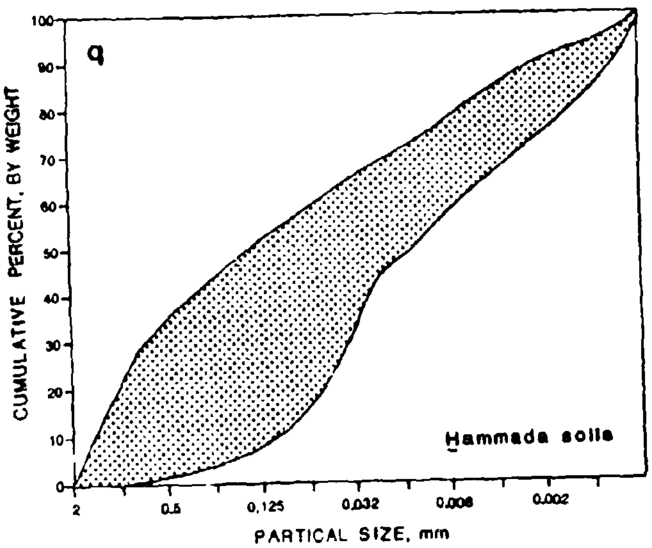

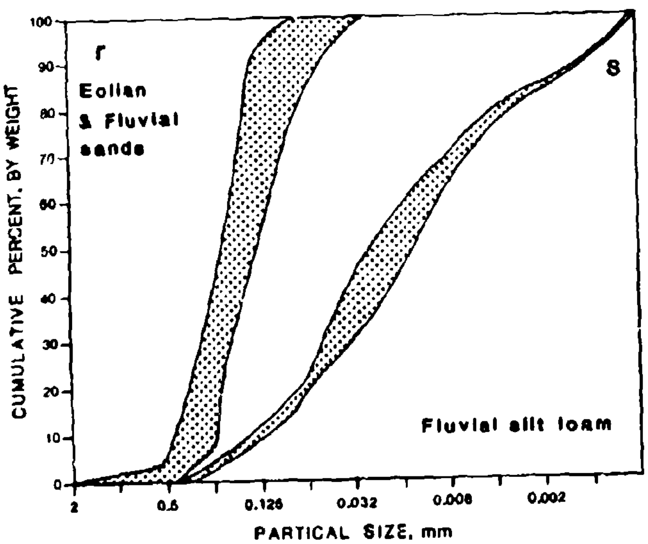

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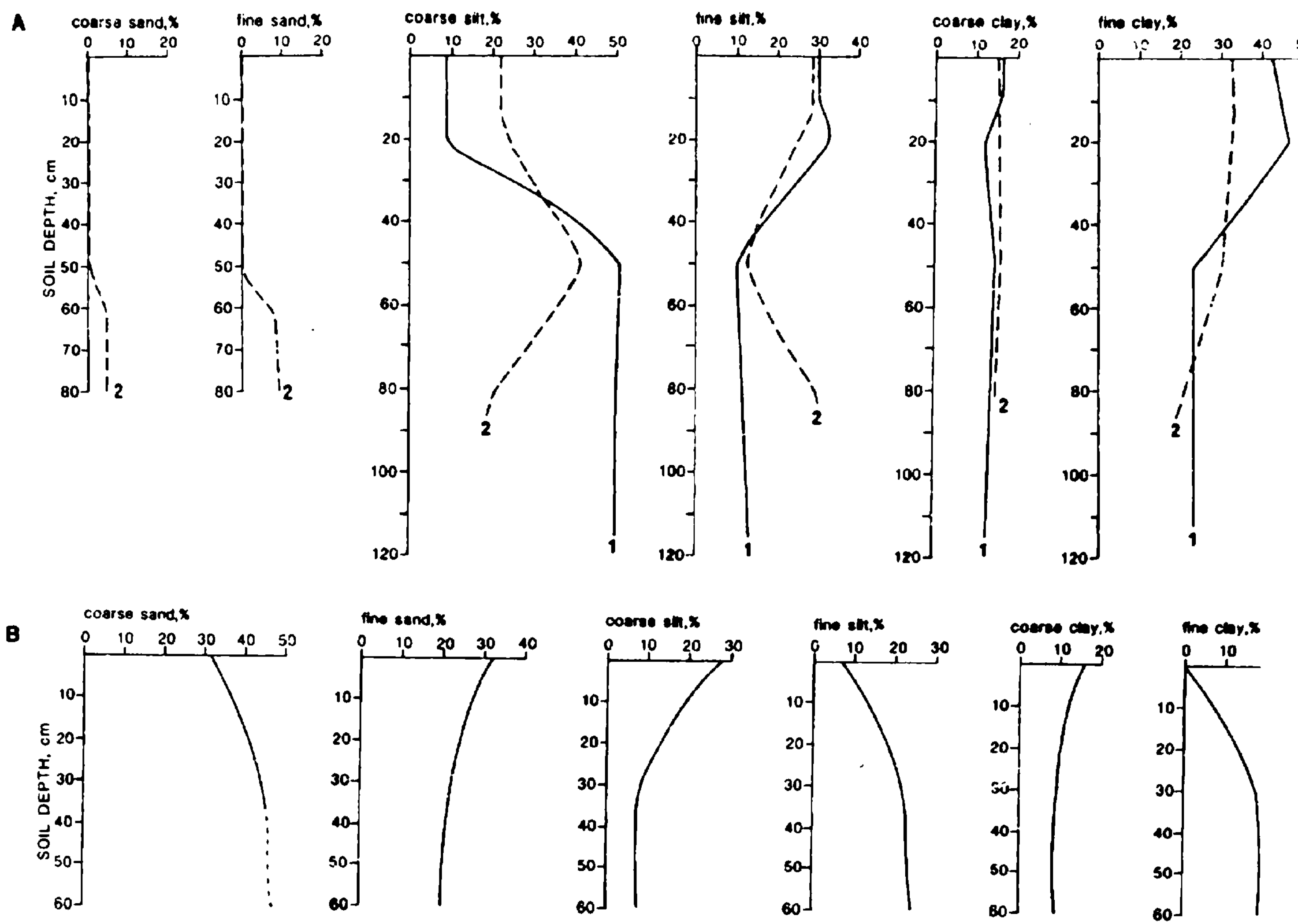


Figure C.1.3. A. Texture, by size fractions with depth, of two Takyr soils in Qa en Naqb, west of the Elat mountains, southern Negev. 1. Center of the playa. 2. The margins of the central playa zone. The finer fractions are more abundant in the upper 0.5 m of the soil profile in the central playa zone.

B. Texture by size fractions with depth, of a sandy Solonchak soil, Bir Sweir, eastern Sinai.

Often there are patches of higher silt concentration at the surface. In Makhtesh Ramon (central Negev) we have observed a 0.1 cm thick crust having 76% sand, 22% silt and 2% clay. deeper — 0.1–37.5 cm — the non-gravelly alluvium is composed of 95% sand, 5% silt and only traces of clay.

The difference in grain sise between the surface and depth in the non-gravelly components is attributed to the effects of additional silt and some clay deposition during the latest stages of flood flows as well as of flows of low discharge and power, which transport only the finer fractions. The surficial layer, usually several tens of cm thick, is frequently affected by scour and fill processes (which occur under relatively high discharge and stream power) and consequently does not contain high amounts of fine fractions. In other cases there is a surficial deposition of fine material during ebbing flows and the uppermost few cm are enriched with silt and some clay. A very high variability with respect to dust content and particle sise distribution is characteristic to recent alluvium.

The colluvial mantle is generally of a cumulative nature. It is subjected to some weathering at its lower horisons, as well as accumulating wind blown and washed-in dust. The resulting profiles are usually Regosols, Lithosols, Reg soils, Serosem soils, as described elsewhere in this chapter.

Reg Soils

Reg soils are silt-loam gravelly soils. They develop on alluvial surfaces usually composed of medium to coarse gravel. The gravel serves as a trap for settling atmospheric dust and salts which penetrate into the surficial deposits and turn them into soils with diagnostic horisons. Usually it is possible to differentiate between young Reg soils (on Holocene alluvial surfaces) and older Reg soils (on Pleistocene alluvial surfaces) by surficial meso and micro-morphology as well as textural composition.

Reg Soils On Holocene Alluvial Surfaces

Holocene Reg soils, being young, reflect the composition of the alluvial parent material in most of their horisones. Only the A horison is closer in composition to settling atmospheric dust, since it is the upper soil horison through which trapped dust is being transferred downward.

Examination of the non-gravelly fractions yields the following average trends (figures C.1.2n,o,p; C.1.4; C.1.5A,B):

1. A_v horison is silt-loam: Silt (49%) > sand (41%) ≫ clay (10%), reflecting the input of settling atmoshperic dust.

2. B horison is loam-silt-loam: silt (46%) > sand (41%) ≫ clay (13%).

3. C horison is usually sandy loam: Sand (62%) ≫ Silt (34%) ≫ clay (5%). The non-gravelly fractions of the parent alluvium are highly reflected.

4. Most of the non-gravelly fractions are relatively coarse grained, consisting of 70–90% sand and coarse silt (>0.016 mm). The silt and clay fractions in the A and B horisons are similar in composition to settling atmospheric dust with -50% coarse silt. The influence of parent material on the C horison is apparent even in the silt and clay fractions because coarse silt comprises some 65–70% of the fines. This shows that the penetration of fine silt and clay has not been very effective.

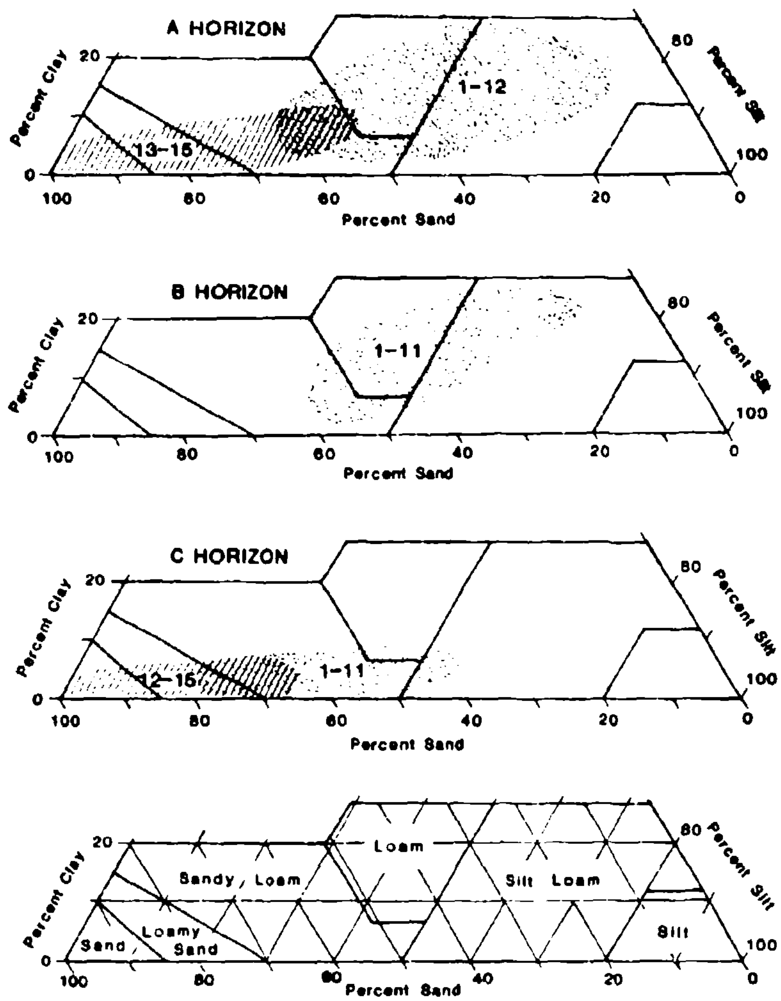


Figure C.1.4. Texture of Holocene Reg soils on the Nahal Ze'elim alluvial terraces. No. 1 - an early Holocene terrace; no. 15 - present-day stream channel.

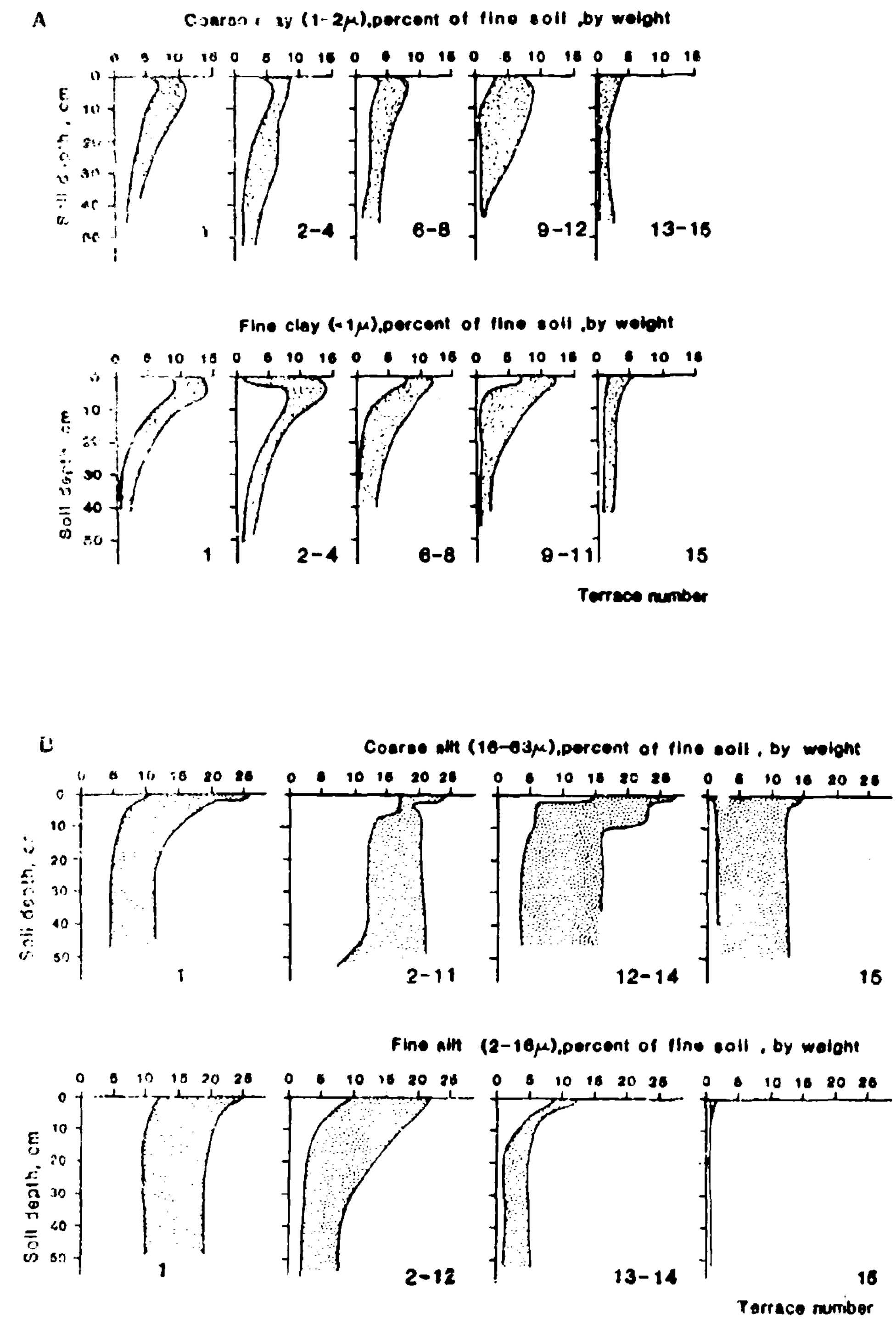


Figure C.1.5. Distribution of various size fractions with soil depth in the sequence of Holocene Reg soils on the alluvial terraces of Nahal Ze'elim. No. 1 - an early Holocene terrace; no. 15 – present-day stream channel. A — Coarse and fine silt. B — Coarse and fine clay.

5. In the A and B horisons there is a higher content of clay than in the C horison. The soils contain 10–15% in the former and less than 5% in the latter. Thus only a small amount of clay is added to the parent material in the C horison, which, in most cases, originally contains less than 2% in its non-gravelly fraction.

Reg Soils On Pleistocene Alluvial Surfaces

Many Pleistocene Reg soils are generally not significantly different from well developed Holocene Reg soils in particle size distribution of the non-gravelly fraction. Only very old soils or those developed in non-sandy environments differ in this respect. Two major points are worthy of emphasis:

1. The soil profile, as well as its discrete horisons, is thicker (fig. C.1.7).
2. There is frequently a B horison which is relatively gravel free (see part D)

Several generalisations regarding the average particle size distribution of the non-gravelly fractions may be presented (figures C.1.2j,k,l):

1. The A horison is also fine in texture. Sand (40%) > silt (35–40%) ≫ clay (15%).
2. The B horison is still finer in texture: silt (40%–50%) > Sand (30%) > clay (20%). It clearly reflects the fines added to the alluvial parent material by penetrating water.
3. The C horison is usually sandy-loam in texture: Sand (Sand (67%) > silt (32%) ≫ clay (10%), reflecting the alluvial parent material.
4. In terrains where there are no adjacent sand bodies that may contribute eolian sand to a given site, the average texture of the soil as a whole is loam to clay-loam: Sand (30–50%) +/- silt (30–60%) ≫ clay (11–25%). For example, on a high Pleistocene surface in the Paran Valley, the texture is: A and B horisons — Silt (50%) > sand (40%) ≫ clay (10%); C horison sand (73%) ≫ silt + clay (27%).
5. In areas adjacent to sandy terrains (sand fields, sandstone exposures) one often encounters sandy Reg soils: the average texture is sand (60–95%) ≫ silt (5–10%). Such soils are abundant in the southern Arava Valley, eastern Sinai and Makhtesh Ramon.
6. As in the Holocene Reg soils, the coarser fractions (> 0.016mm) are dominant. The average content in the A horison is 75%, in the B horison 70% and 82% in the C horison. The finer fractions (< 0.016mm) comprise only 18–30% of the non-gravelly material.
7. One finds fine fractions similar in composition to average settling atmospheric dust in the A horison where coarse silt is about 50% of the total silt and clay content. In the B and C horisons of Pleistocene soils it is approximately 40%, whereas in Holocene Reg soils a 6?% content is more common.

Some Conclusions

The texture of the non-gravelly fractions of Quaternary Reg soil in the Negev and Sinai is generally loamy. Variations from this generalisation result from several conditions:

1. Sand contribution from near-by sandy terrains such as flood plains, eroding alluvial terraces, sand fields and exposures of sandstone. The resulting texture in such cases is sandy loam.
2. Differentiation within the soil profile due to the formation of genetic soil horisons; for example C horison is usually sandy-loam with low clay content, reflecting the texture of the alluvial parent material. The A and B horisons are close in texture, with the latter being slightly higher in clay.

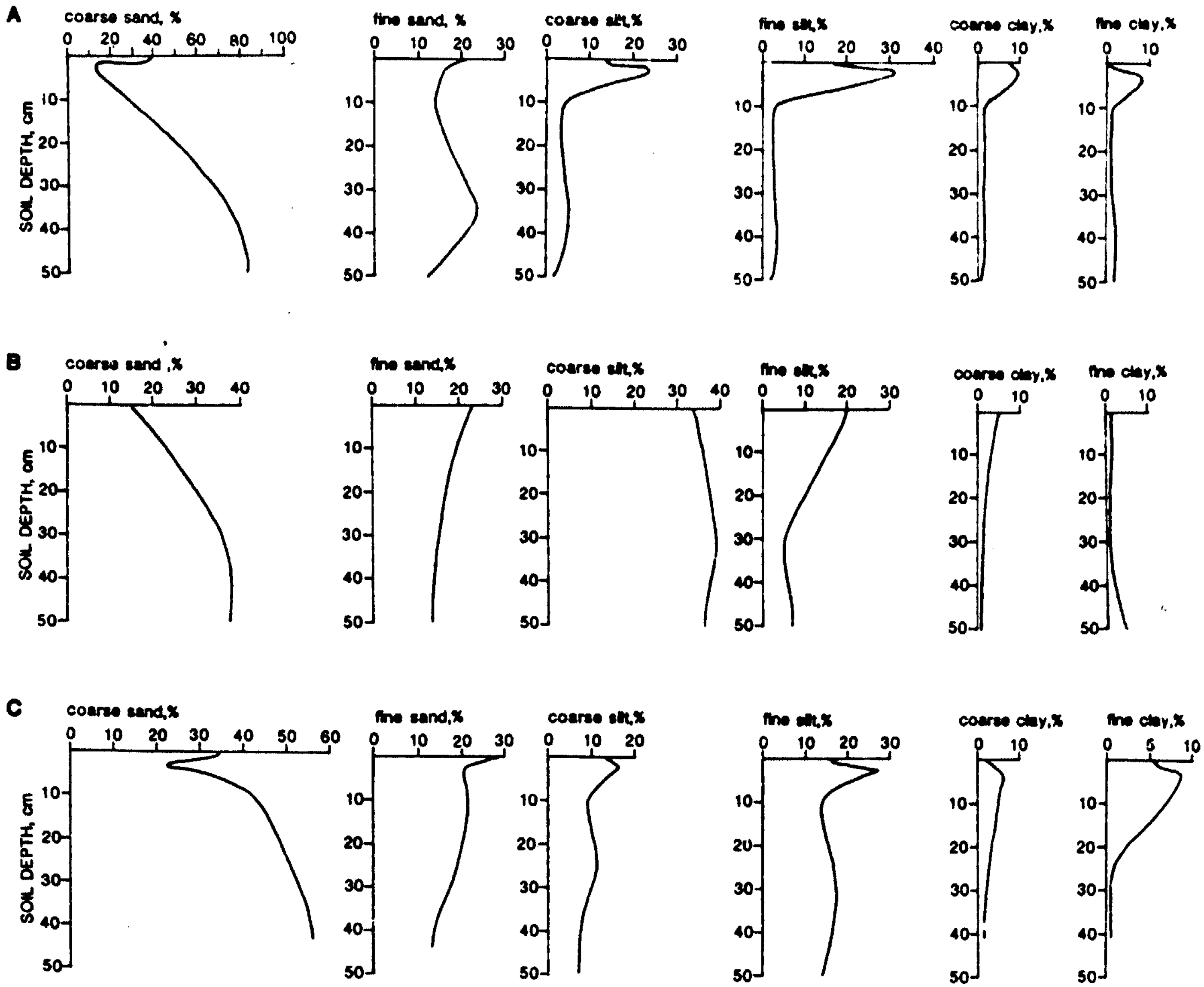


Figure C.1.6. Distribution of size fractions with depth, in Reg soils on early Holocene alluvial surfaces in Wadi Mukeibilia, eastern Sinai (A,B) and Timna valley, southern Negev (C).

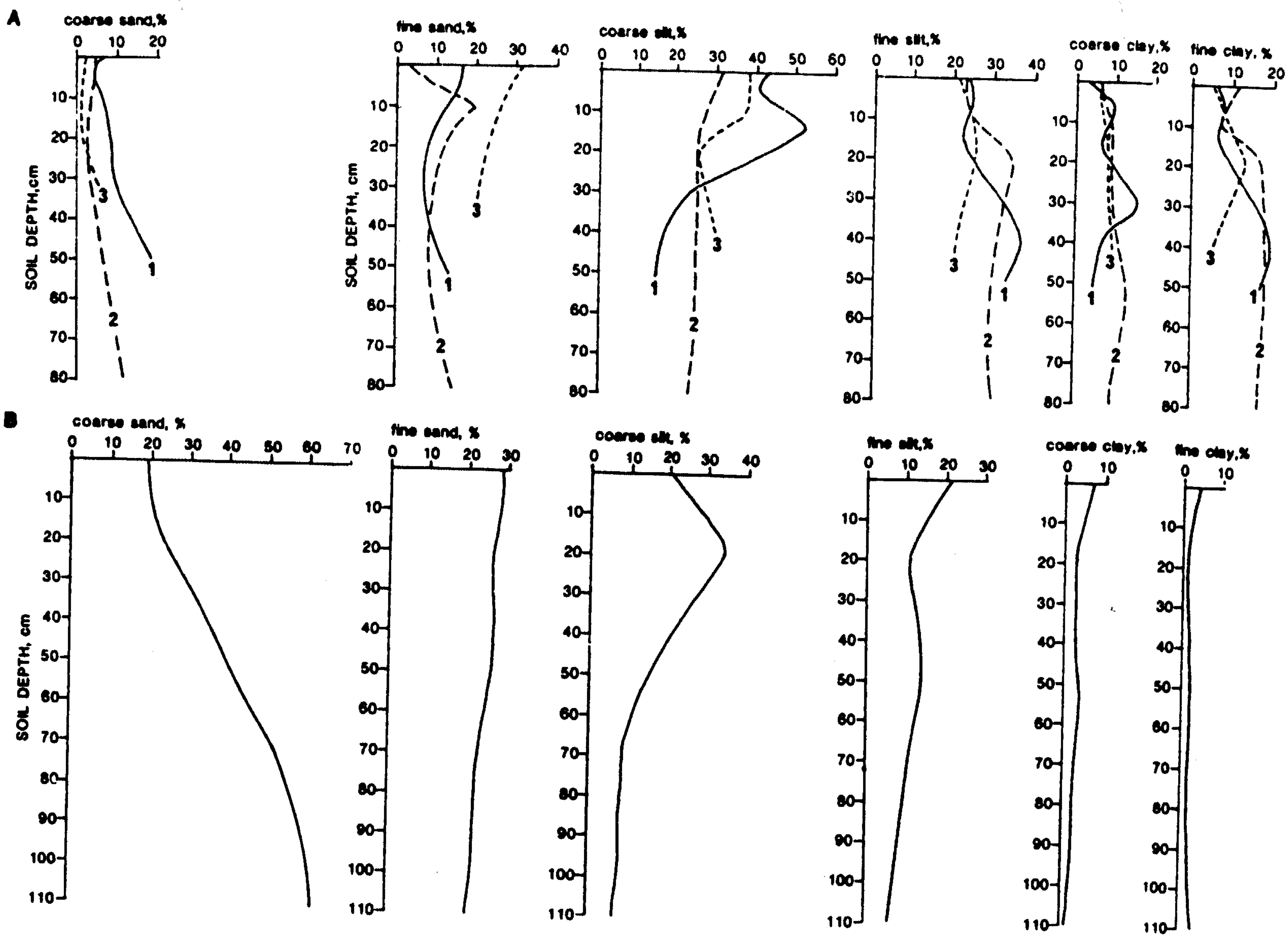


Figure C.1.7. Distribution of the various size fractions with depth, in Reg soils on Pleistocene alluvial surfaces: A. Three soil profiles in the Zin Valley, central Negev. B. A soil profile in the Timna Valley, southern Negev.

3. Age. This factor is significant within a given Quaternary soil chronosequence, but may be obscured on a regional scale by conditions (1) and (2) above.

The trends in evolution of Reg soil texture with time are observed in soil chronosequences on flights of alluvial surfaces. Young Holocene Reg soils (< 2000 years old) do not show clear horizonation but there is a distinct decrease in the contents of silt and clay with depth even in very young soils.

Textural differentiation is accentuated with time, as fine fractions accumulate in the upper horizons, at depths of 0–5 cm (less frequently — 0–10 cm) with 25–45% silt and 10–20% clay in the B horizon. Usually there are two patterns of textural changes with depth (figures C.1.5A,B; C.1.6; C.1.7):

1. An increase in the content of silt and clay from the A horizon to the B horizon, and then a decrease into the C horizon;

2. A decrease with depth having no clear peak below the A horizon. Additionally, fine sand (0.063–0.250 mm) changes in a manner similar to silt and clay rather than that of coarse sand.

Pleistocene Reg soils show similar evolutionary trends with time. In areas not affected by adjacent sandy terrains there are higher amounts of silt and clay in the soil profile and the horizon of peak content (B) is deeper by about 10–25 cm.

The rates of addition of fines to the soil profile are rather high at the initial period of soil evolution (2000–4000 years) but become lower with time (figures C.1.8,9). Examination of a Holocene soil chronosequence in Nahal Ze'elim (Dead Sea) shows that during the later stages of soil evolution there may be a very slow change in texture. It takes many thousands of years for a Reg soil to show a distinct differentiation in texture between discrete soil horizons. Climate certainly has a major role in the process. It appears that the relatively better developed soils on the Pleistocene alluvial surfaces evolved under an arid to moderately arid climate. Many of these soils are now under an extremely arid climatic regime.

The age determination of most Reg soils in the Negev and the Sinai is still in question, since datable material is missing. Only a certain seperation of the Holocene from the Pleistocene Reg soils is certain (Gerson and Amit, 1981; Gerson, 1981; 1982; Amit, 1982; McFadden, 1982; Bull, in preparation). Age differentiation based on relative indicators is still in progress (Amit and Gerson, 1985).

The polygenetic nature of most Reg soils on pre-Holocene alluvial surfaces still precludes a sound time-frame that may be projected from one region to another.

There is a very high variability in the textural nature of Reg soils. Several reasons for this situation are:

1. The variable nature of parent material between regions and alluvial surfaces.

2. The variation in amounts and composition of incoming dust, which is related to sources, atmospheric conditions and climate.

3. Large local variation in parent material affecting hydrologic characteristics and dust trap efficiency.

4. Surficial morphology, determining roughness, settling of dust, and surficial runoff, makes the surface highly variable.

All these render many Reg soils of different ages very similar in texture, or conversely soils of the same age, on the same alluvial surface, highly variable (fig. C.1.8).

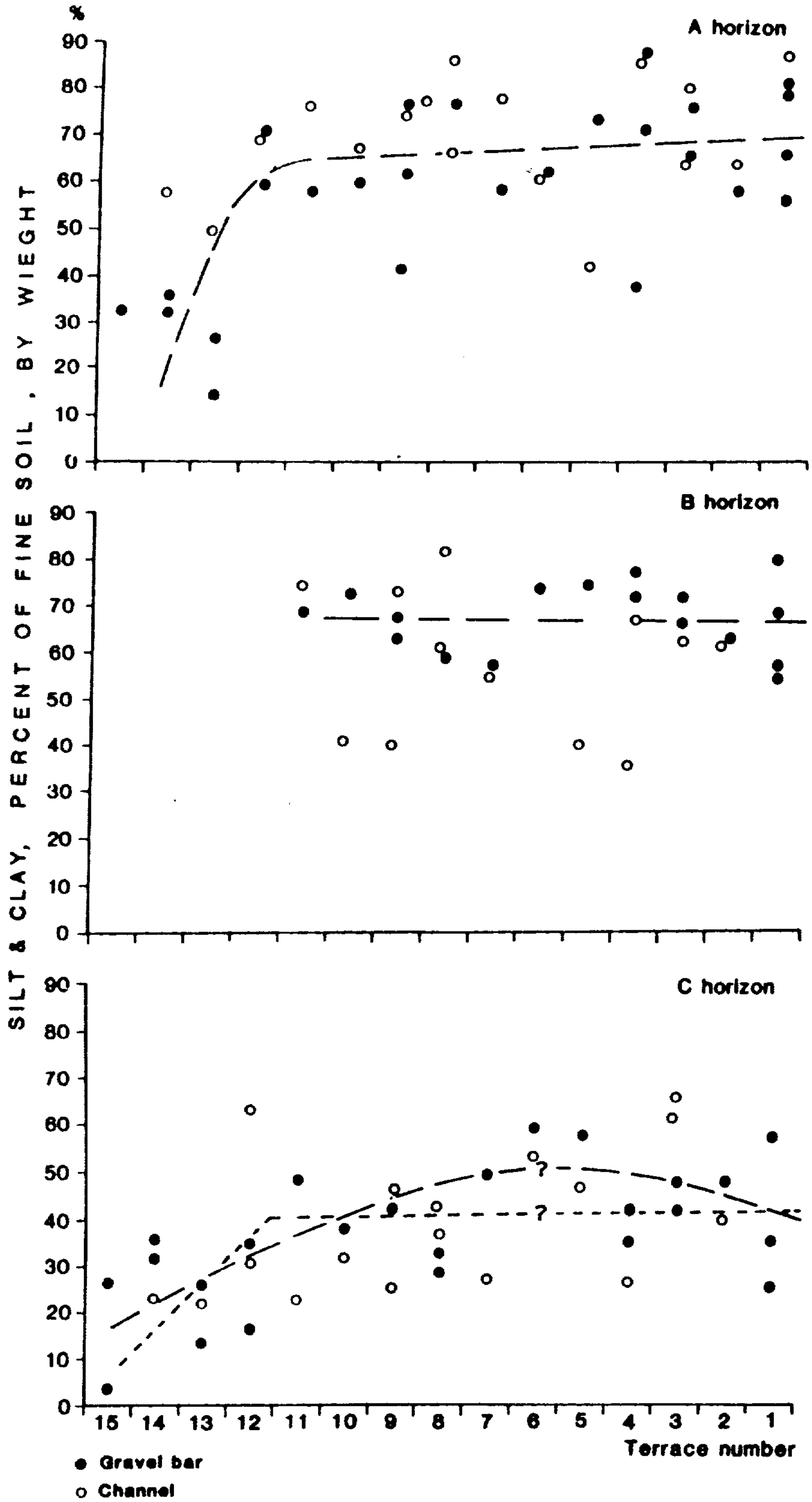


Figure C.1.8. Change of silt + clay content in the fine earth fraction in Reg soils, on the Holocene terrace sequence of Naḫal Ze'elim (Dead Sea area) in the A, B and C horizons. No. 1 – early Holocene terrace; no. 15 – present-day channel.

In addition there is no good correlation between the contents of silt and clay in Reg soils. Several reasons may account for this situation:

1. Differential ratios in the parent material.
2. Varying proportions in the added atmospheric dust.
3. Differential movement of various fractions, a function of the hydrologic conditions within the soil, and changing environmental regimes with time and climatic fluctuations (see chapter E.1).

A general conclusion, then, is that only under a very narrow set of unchanging environmental conditions or under the influence of one dominant factor may the textural composition of the non-gravelly fractions be predicted. For example, in areas where sand contribution to both the alluvial parent material and the atmospheric dust is relatively high, we can predict the resulting soils to be of a sand-loam texture. In most other terrains the soils are highly variable in texture.

Hammada Soils

Hammada soils are usually silt-loam (sometimes loam) gravelly soils, of the ABR, ACR or ABCR type, formed on flat or gently sloping hard bedrock surfaces (figures C.1.1B, C.1.2q). Occasionally they consist of soil pockets underlain and enclosed by bedrock blocks. When well developed these soils may have a gravel-free B horizon underlying a gravelly desert pavement and a vesicular A horizon (plate 11A).

On the average there is a certain textural differentiation between the various horizons: The A horizon is silt-loam: Silt (57%) > sand (30%) > clay 13%. The B horizon is usually loam or silt-loam: silt (50%) > sand (31%) > clay (19%). The C horizon is sandy-loam: sand (53%) > silt (32%) > clay (15%).

The ratio between coarse silt and fine silt + clay decreases with depth. It is 1:1 in the A horizon, as in average settling atmospheric dust, 1:1.7 in the B horizon, and 1:2.3 in the C horizon. Some migration downward of the fines fractions is evident.

Within a generally wide textural spectrum of Hammada soils it is possible to distinguish two groups:

1. Silt-loam or loam Hammada soils, occurring in areas where eolian dust is derived from distant sources (as in the soils of the central Negev plateaus).
2. Sandy-loam Hammada soils, which are affected by adjacent source areas of sand (such as the sandstones exposed in Makhtesh Ramon or in the Arava Valley).

Lithosols

Lithosols, are shallow stony soils, of AC,ACR or CR horizons, which usually overlie soft bedrock, and reflect a mixture of weathered bedrock and introduced dust and salts. Thus, lithosols are very diversified in texture. In the Sde Boker (northern Negev) area, where limestone and chalk are the major bedrock types, one finds a variety of Lithosols (Arsi, 1981; fig. C.1.10).

These include:

1. Lithosols which contain large amounts of eolian dust, developed mostly on hard limestone;

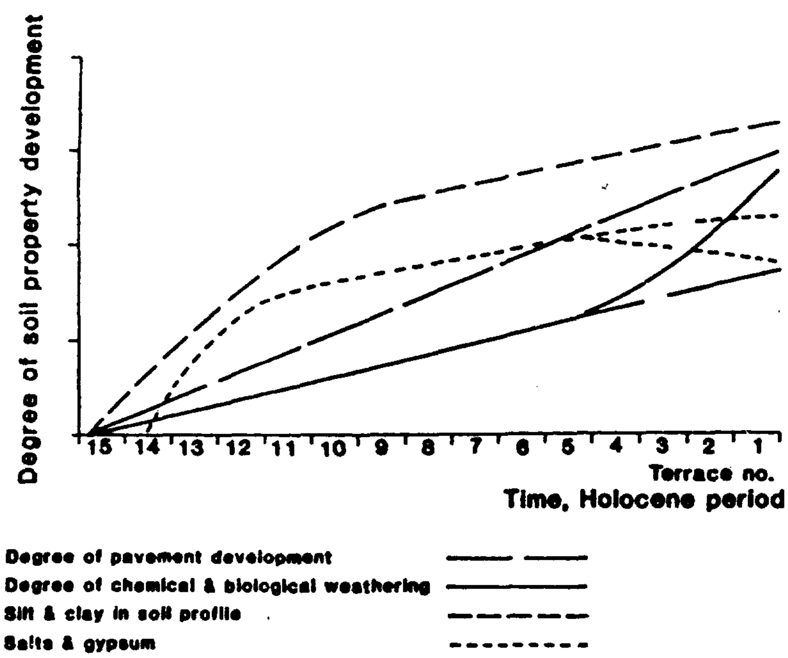


Figure C.1.9. Change of several soil profile properties with time on a sequence of 15 Holocene alluvial surfaces of Nahal Ze'elim (Dead Sea area). Terrace no. 1 – early Holocene; no. 15 – present-day channel.

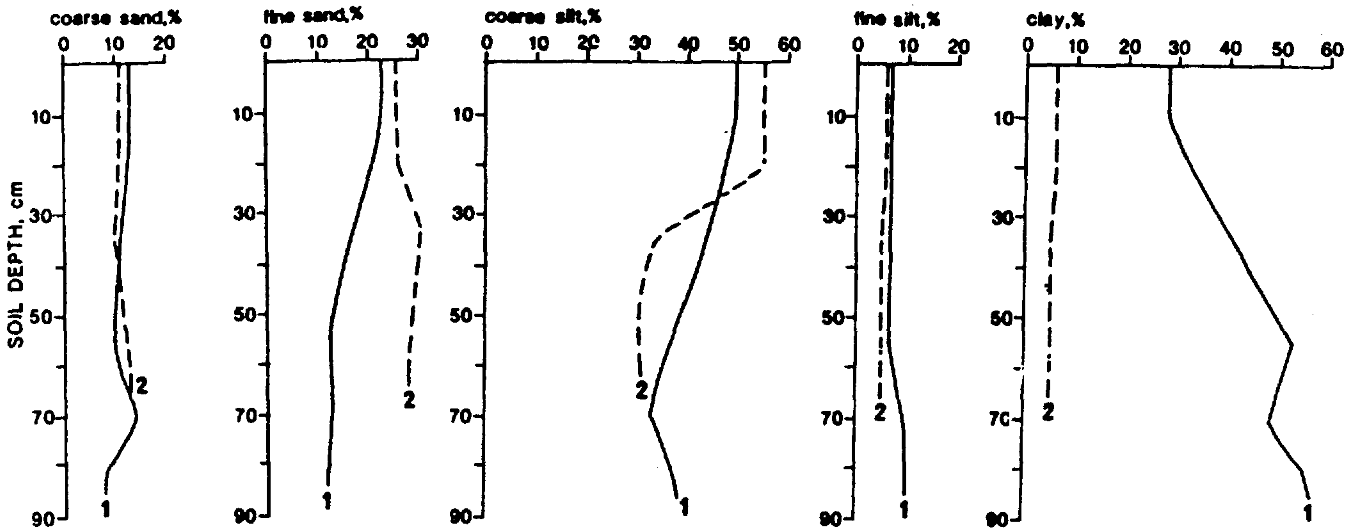


Figure C.1.10. Distribution of size fractions with depth, in two lithosol profiles on a hillslope in Sde Boker (data from Arsi, 1981).

2. Lithosols with large quantities of weathered chalk, in which much of the non-gravelly fractions are derived from the underlying friable rocks.

In the northern Negev and the Judean Desert the average texture of the non-gravelly soil material is usually loam (A horizon) and clay-clay-loam (B and C horizons. Arzi 1981; Dan and Smith 1981). The average composition is:

A horizon: Sand (42%) > silt (38%) > clay (20%)
B horizon: Clay (43%) > sand (32%) > silt (25%)
C horizon: Clay (40%) > sand (30%) = silt (30%)

The ratio between the coarser fractions (sand and coarse silt) and the fine fractions (fine silt and clay) is different from the ratios for most aforementioned soils: A horizon — 2.3:1; B and C horizons — 1:1. This is a result of the high combined amounts of clay from both the chalky bedrock and the eolian dust. Additionally, water contributed from rocky exposures to soil patches enhances the weathering process. However, the high precentage of sand in the A horizon and the relative contribution of clay and silt by the weathered bedrock have yet to be studied.

Seorzem Soils

Serozem soils are light coloured aridic soils of the ABC or ABB_b type having a calcic and/or gypsic horizon at shallow depth. Hence, they are very diversified in their texture. Most of them are loessial and/or stony in nature.

The serozem soils of the Negev are usually fine grained in their non-gravelly fraction wherever located away from sand contributing terrains. Silt and clay constitute 65–80% and most of the remainder is fine sand. The lower horizons usually contain more clay (<40%) but conversely may also contain more sand than the upper horizons. A mixture of materials from various sources is apparent, with sand from weathered parent rock or colluvium and fines from eolian dust.

Sands: Eolian And Derived Colluvial And Alluvial Sands

In terrains of active eolian sand transport, such as sand dunes, the amounts of trapped silt and clay are very small. For example, there is less than 0.1 % to 0.7% in the coastal dunes in northeastern Sinai and 0.7–2.6% in the inland sand dunes further south (Tsoar, 1970). Similar contents (0.6–1.2%) were observed in the inland sand dunes of the western Negev (fig. C.1.2r).

A different particle size distribution is observed in stabilized sand dunes (fig. C.1.11). Stabilized sand dunes in the western Negev contain 5–10% silt and clay down to a depth of 40 cm (Tsoar, personal communication). The highest content (10%) is observed at the surface. In one instance it was observed that the sand in climbing dunes on steep hillslopes contains 7% of fines. Restricted sand and dust movement in these landforms (climbing dunes) may be a cause for such a content.

In stream channels and flood plains which cross sand dune fields, one usually finds two types of non-gravelly deposits (fig. C.1.12):

1. Sand with some silt and clay (10–25%), which is typical of sedimentation in the channel during floods (fig. C.1.2s).
2. Silt (and clay) with some sand (10–20%) deposited overbank during high flows, and in the channel during very shallow flows.

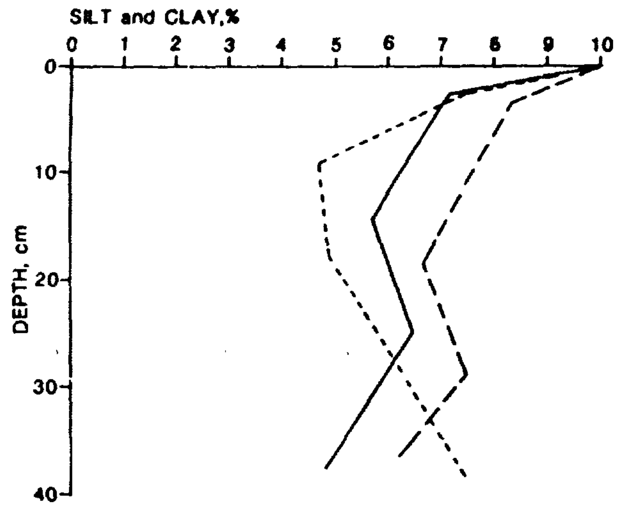


Figure C.1.11. Silt and clay content with depth, in stabilized dunes in the western Negev (from H. Tsoar, unpublished).

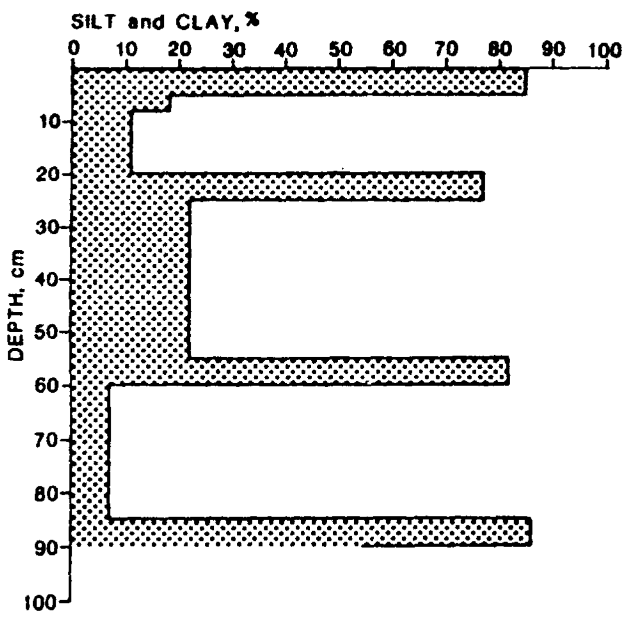


Figure C.1.12. Silt and clay content in a flood plain of a stream channel crossing a sand field near Yotvata, southern Arava Valley. The remaining material is sand (see a photograph in Plate 12B).

In soils developed on alluvial sands in the northwestern Negev we find an average of 20% fines in A and B horizons, and only 5% silt and clay in the C horizon; (fig. C.1.13; Marish et al., 1978). This may be attributed to the fact that the C horizon is actually a stabilized sand surface.

Gravelly Regosols On Sieve Deposits

Sieve deposits, having large pores and being highly pervious, serve as very efficient traps for dust from various sources:

1. Eolian dust settling from the atmosphere;
2. Dust penetrating with infiltrating rainfall;
3. Dust washed-in with running water.

In the southern Arava Valley and eastern Sinai we usually find the following textural compositions: Sand (60–80%) $\gg$ silt (20–30%) $\gg$ clay (3–7%).

The large pores in sieve deposits allow a free penetration of available sand. In some areas, we find a finer non-gravelly matrix, for example the textural range in Mount Amram (southern Negev) is : sand (48–55%) > silt (37–42%) $\gg$ clay (5–12%). It may well be that the type of gravelly trap is the reason for this finer texture. In the Mount Amram area the sieve deposits are composed of fine to very fine and well sorted gravel.

There is usually a general decrease in the content of fines with depth. The upper part of the section, near the surface, contains 50–60% silt and clay whereas most of the section usually contains 30–40%. The composition of fines is similar to that of average atmospheric dust; the ratio of coarse silt to fine silt + clay is ~1:1 throughout the section. Differentiation in the fine fractions along the section does not occur due to the high porosity of the gravel.

Paleosols

Paleosols are soils which have formed in landscapes of the past (Yaalon, 1971). Most of the paleosols encountered in deserts are identified by their buried B and/or C horizons. They are characterised by their color, texture and added salts, and compared to overlying or underlying horizons. More difficult is the identification and definition of relict paleosols, which are at the surface thoughout their evolution. Such is the case of polygenetic Quaternary Reg soils, beginning their evolution sometime in the Pleistocene, developing through varying climate regimes, and undergoing slow transformation during the extremely dry Holocene period.

In the loessial soils of the western Negev there is a tendency for B_b (= buried B) horizons to contain 10–15% more fines than the overlying B or C horizons, and 15–20% more fines than the active A horizons (fig. C.1.14,15).

Summary And Conclusions

The non-gravelly materials in desert soils are derived from three sources: weathered parent material, airborne dust and airborne salts. The composition of the fine earth fractions and their particle size distribution in the soil is a result of the behavior of the various forming agents — weathering, wash and infiltration. The relative importance of these agents changes with time, since the nature of the soil is also time-dependent.

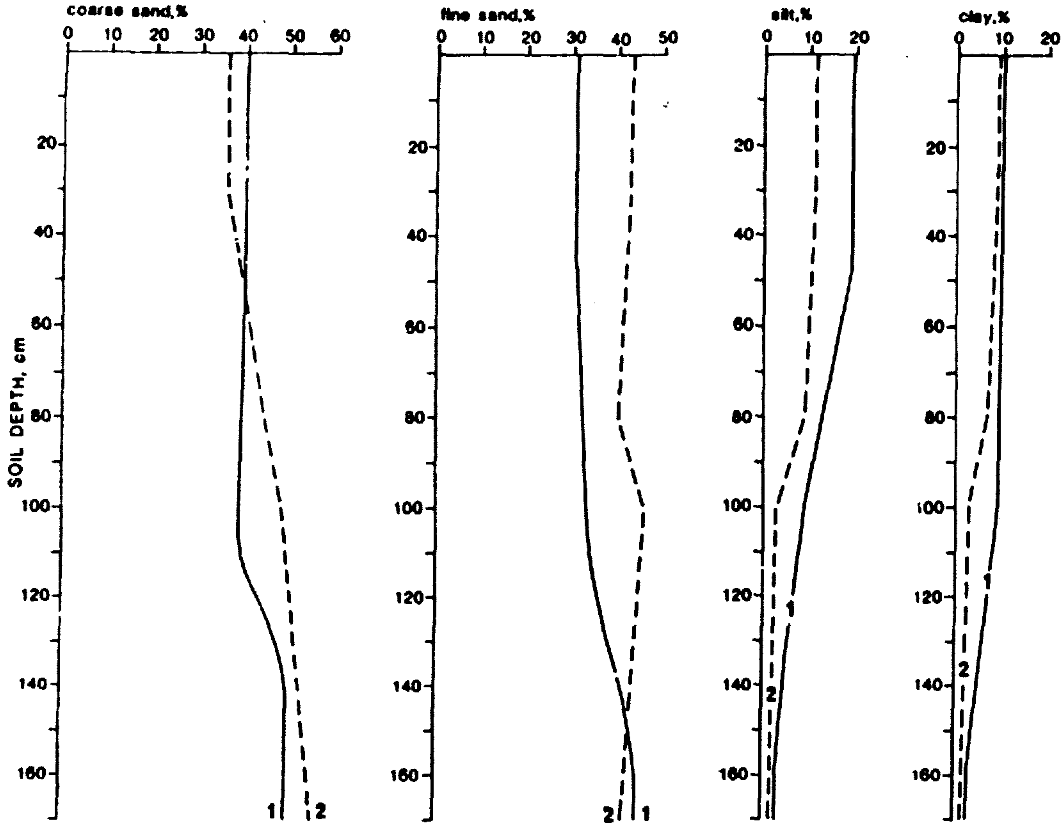


Figure C.1.13. Size distribution by fraction, with depth, in sandy soils in Western Negev: 1. Be'eri 2. Kissufim. (data from Marish et al., 1978)

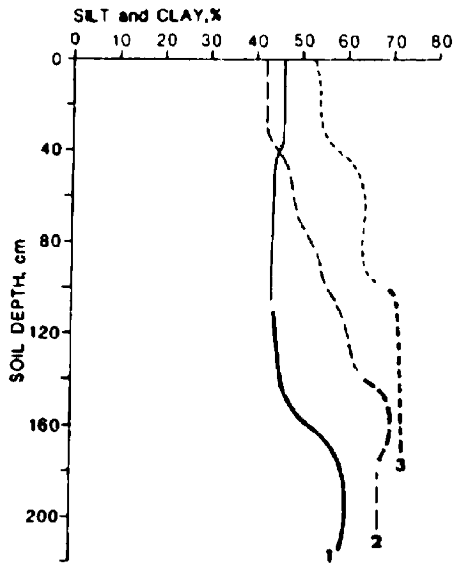


Figure C.1.14. Silt and clay content in three loessial soils in the western Negev. The thicker portions of the curves denote buried B horizons: 1. Loessial Serozem soil. 2. Brown Loessial soil. 3. Light Brown loessial soil. (data from Dan et al., 1972 and Marish et al., 1978)

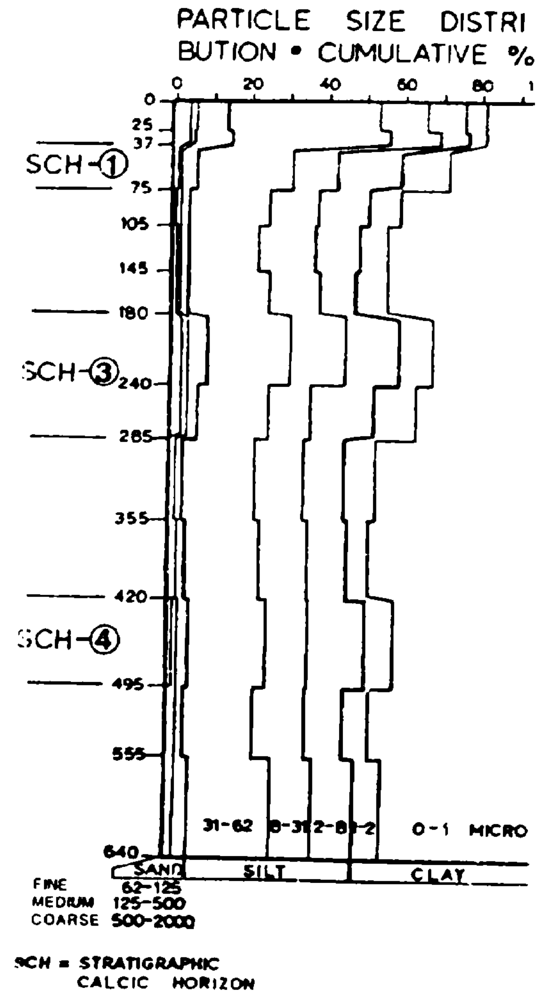


Figure C.1.15. Particle size distribution, by fraction with depth, of a sequence of buried loessial paleosols in Netivot (northern Negev; after Bruins, 1976)

The prediction of the general composition and distribution of the fine earth materials requires consideration of the relative importance of mainly five general factors: parent material and its properties; sources; mode and accumulation rate of allochtonous materials (sand, dust, salts); climate, as it affects the hydrologic regime at and close to the surface; time, within which climate may fluctuate and soil properties change. Examples of the significance of the various factors are: (a) sandy loessial soils in the northwestern Negev which are proximal to sand fields; (b) sandy Solonchack soils in playas and sabkhas which collect runoff water and sediment from watersheds in which sandstone exposures are abundant; (c) dust-rich gravelly soils in areas with no near by sand sources; (d) a significant increase of soil salinity with soil age; (e) significantly thicker soil profiles on old landforms which have existed under relatively humid climatic regimes (moderately arid, semi-arid); (f) the types of salts which appear in the non-gravelly fractions change with climate; for example, $CaCO_3$ occurs in the less arid terrains and gypsum-chlorides in the desert soils (see chapter C.3). Generally, the predominance of long distance airborne dust results in the fine earth being silt-loam, silt and clay loam in texture.

Several generalisations can be presented with respect to the amounts and nature of dust in different aridic soils (figures C.1.1, C.1.16, C.1.17):

1. Loessial soils and Takyr soils are composed mostly of dust-sized fractions. Their composition is close to that of settling atmospheric dust (see Part B).

2. Hammada soils and Holocene Reg soils are similar to settling atmospheric dust in the composition of the non-gravelly component of their A_v and B horizons. This is so in terrains where the parent material and location are not associated with sand contributing sources.

3. Generally, Reg soils are most variable in the texture of their non-gravelly fractions. This is due to the great diversity of parent material and the widespread spatial distribution with respect to different sources of airborne materials.

4. Generally, deposits with the lowest content of dust are charachteristic of alluvium in flood plains of streams draining watersheds in which hard (non-friable) rocks are exposed. These are typically composed of gravel, sand and very little dust. Young sandy Regosols and sandy / gravelly Solonchaks are usually also poor in dust content.

5. Gravelly Regosols on sieve deposits and many Hammada soils contain medium amounts (50–60%) of dust in their fine earth fraction.

Examination of the clay/salt ratios in the various soils yield the following groups (fig. C.1.16):

1. Low ratios of 0–0.4 occur in the non-gravelly fraction of coarse desert alluvium, Reg soils on Holocene alluvial surfaces, and many Hammada soils. The ratios are within the range charachteristic of settling atmospheric dust (see part B) which is high in silt and low in clay.

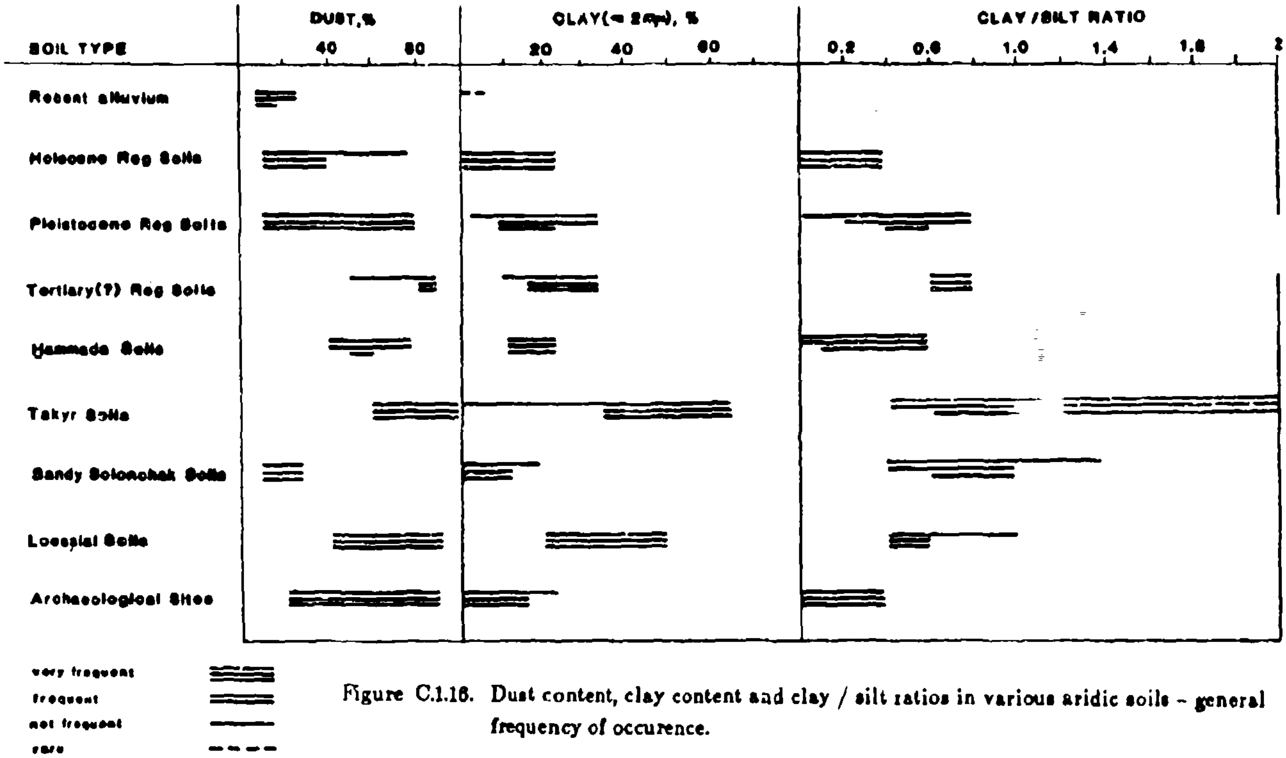


Figure C.1.16. Dust content, clay content and clay / silt ratios in various aridic soils – general frequency of occurence.

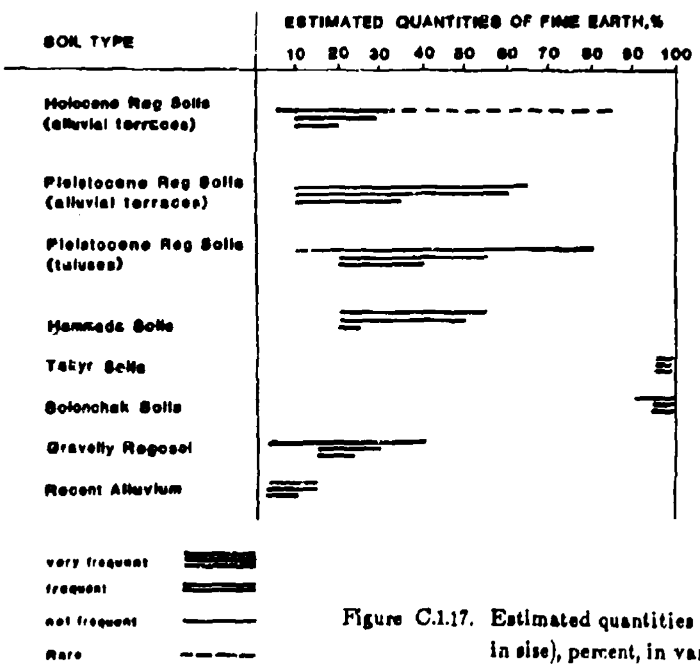


Figure C.1.17. Estimated quantities of fine earth (<2 mm in size), percent, in various desert soils.

2. Medium ratios 0.4–0.6 are charachteristic of loessial and mature Reg and Hammada soils, in which some clay accumulation is evident.

3. High ratios — 0.6 and usually $\leq$ 1.0 — are typical of some Takyr and Solonchak soils in areas where relatively high amounts of suspended clays are deposited.

Generally the correlation between the content of silt and the content of clay in the fine earth fraction is rather low for most desert soils, due to the following reasons:

1. The size distribution of settling atmospheric dust is heterogeneous through time and space (Ganor, 1975).

2. There is a filtering process as dust is added to the soil profile. Various dust fractions move through the soil at different rates and to different depths. Clay films observed in loessial soils and well developed Reg soils are indicators of clay translocation. Thus, clay/silt ratios of the original added dust change due to these processes.

Figures C.1.18,19 may demonstrate the above effects. Holocene Reg soils containing dust that has settled recently and infiltrated through a rather open gravelly texture, reflect the variabilty in clay/silt ratios typical of settling atmospheric dust. The lesser degree of correlation between clay and silt in older Reg soils reflects the effects of both fluctuating climate through time and filtering through a developing soil.

Some very broad trends appear in the behavior of the various size fraction in desert soils, as shown in figure C.1.20:

1. There is a general decrease in the content of a given fraction as the particle size of its material becomes smaller, from coarse silt to fine clay. This trend is clear in A and C horizons. It is less so in B horizons, when comparing fine silt with coarse clay. It may well be that these trends exist because A and C horizons in desert soils are similar to the source of the dust material, whereas B horizons have undergone more alteration than A and C horizons.

2. The trends, by particle sizes, are:

(a) Coarse silt — a relatively large component (up to 55%); there is a decrease in silt content from the A horizon to B horizon to C horizon.

(b) Fine silt — a lower content than coarse silt (<40%, but usually less than 30%); there is a decrease from the upper (A) to the lower (C) horizons.

(c) Coarse clay — low amounts (<15% but usually less than 10%); there is a low rate of decrease from the A to B to C horizons.

(d) Fine clay — relatively large amounts may occur in the A and B horizons ($\leq$ 50%, but most soils contain less than 15%); The C horizon usually contains less than 10% fine clay, but some soils may contain up to 30%.

(e) % coarse silt >% fine silt <>% fine clay $\gg$ % coarse clay.

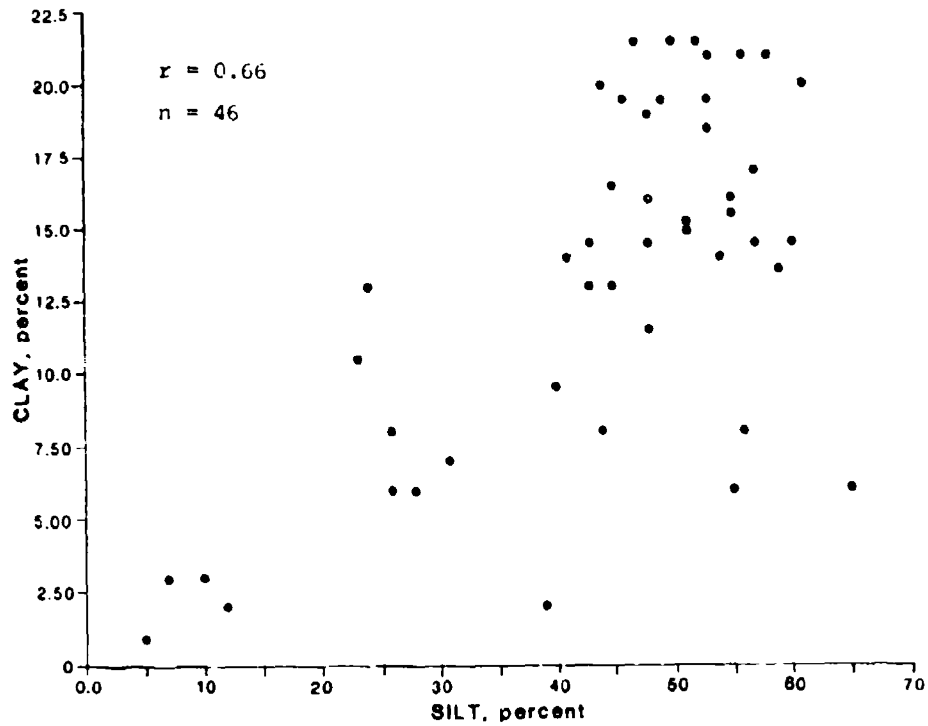


Figure C.1.18. The correlation between clay content and silt content in the B horizon of Holocene Reg soils.

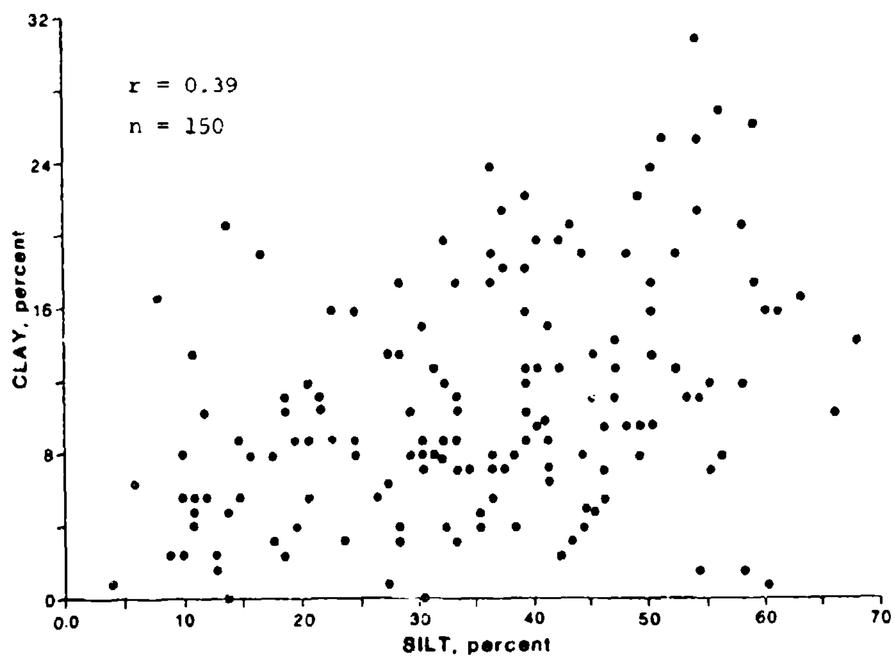


Figure C.1.19. The correlation between clay and silt content in Reg soils on Pleistocene alluvial surfaces.

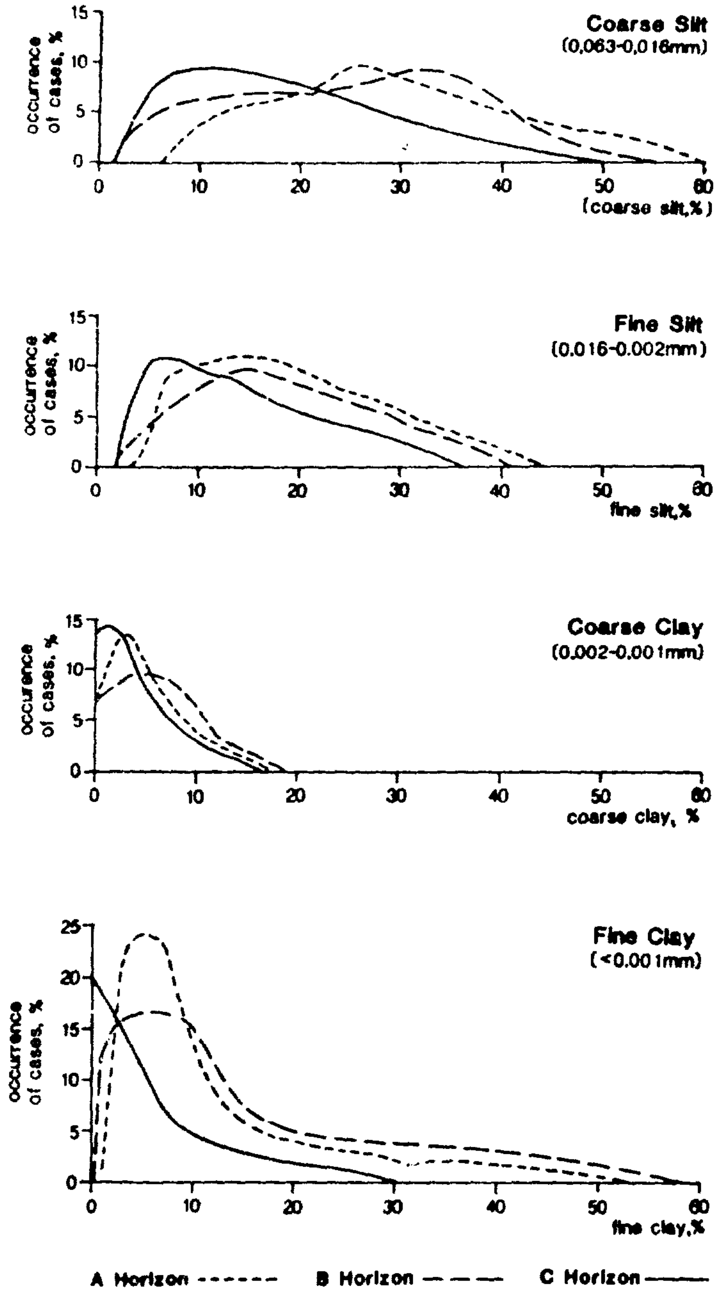


Figure C.1.20. The frequency of occurence of the various size fractions in aridic soils – general trends (based on 200 soil profiles).

C.2 MINERAL COMPOSITION OF DUST IN DESERT SOILS

The mineralogical composition of soils and surficial deposits may strongly reflect the environmental conditions and the evolution of the landscape at a given site. Environmental changes through time may be traced by the relative abundance of different mineral species and their degree of preservation.

The mineral composition of the dust particles in desert soils is determined by three main factors:

1. The composition of the introduced airborne dust. This factor is decisive in most arid terrains since much of the fine fractions are derived from settling atmospheric dust.

2. Parent material at the site in question; the bedrock or the original surficial deposit is also reflected in the mineralogical composition of many desert soils.

3. The climatic regime — past and present -- is certainly a significant factor. It may affect, or even determine, dust mineral composition through modes and rates of alteration of primary and secondary rocks, as well as modes and rates of long distance transport and deposition.

The mineral composition of dust fractions in the desert soils and deposits of the Negev and Sinai is generally the following:

1. The silt fraction is composed mainly of quartz (40-60%), calcite (25-40%), some feldspars (3-10%) and dolomite (0.5-6%). The ratios between major constituents — quartz and calcite — change considerably with different soil profiles and horizons, with no decisive trends. Only in calcic horizons in loessial soils does the ratio shift toward somewhat higher amounts of calcite (Bruins, 1976).

2. In fine silt (0.016-0.002mm) there is a much lower quartz content than in coarse silt (0.063-0.016mm; Goldberg, 1984, personal communication).

3. The clay fraction in most desert soils in the Negev contains primarilly montmorillonite and substantial amounts of kaolinite. Illite is a minor constituent and palygorskite appears in some samples. This is true in the cases of the loessial soils in the northern Negev (Bruins, 1976) and most of the Reg soils in the Negev and in the Dead sea area (table C.2.2). This typical composition is determined by the weathering products of the widely exposed upper Cretaceous Paleocane and Eocene rocks in the Negev (Nathan, 1966) as well as in the Sinai and North Africa.

The contribution of certain rock types or formations is evident in many Negev soils:

1. The high amounts of calcite are derived from the formations of limestone and chalks widely exposed in the desert terrains of North Africa, the Sinai, the Negev and the northern Arabian desert (for example table C.2.1).

2. Various silicate minerals such as quartz, feldspars, plagioclases, heavy minerals, are abundant in the sand and silt fractions of soils deposited in close proximity to exposures of igneous and metamorphic rocks. These minerals are especially prominent in terrains downstream and downwind from such exposures. However, since much of the dust in most desert soils is derived from distant sources, one may always find calcite, dolomite, and clays derived from terrains in which marine sedimentary rocks are widely exposed.

3. Large amounts of kaolinite are released by the disintegration of Paleozoic and early Mesozoic (Nubian) sandstone formations, in which kaolinite clay is found as a binding agent. The finer fractions of the dust in the derived soils (whether formed from the original detritus or developed through the accretion of airborne dust) are rich in kaolinite (Singer & Amiel, 1974).

4. Palygorskite is derived from certain shales and chalks of uppermost Cretaceous – lower Tertiary rock formations (Nathan, 1966; table C.2.1). This mineral is found in substantial quantities in soils derived directly from the above mentioned formations. However, since palygorskite is not a stable mineral in the desert soil environment, it is not found in significant quantities in the clay fractions of old desert soils (see table C.2.2).

5. Past climatic regimes are reflected in the mineralogy of certain paleosols. One example is the occurrence of pockets of Pliocene(?) – early Pleistocene(?) Terra Rossa in the Negev Highlands. This area is now under an arid climate (90–120mm/year of mean precipitation). Large quantities of kaolinite (sometimes well crystallised) are typical of these soils, developed under a subhumid (humid?) or a Mediterranean climate on limestone formations. Another example is the large component of kaolinite in red and calcic paleosols preserved in extremely arid environments in the western Negev (see table C.2.2). Semi-arid to subhumid climates are probably the regimes under which these soils have initially developed.

In summary, the most abundant minerals in the dust of desert terrains in the Negev and Sinai are: quartz, calcite, feldspars, dolomite and montmorillonite. Other minerals appear in rather low quantities, except in special cases related to particular source rocks or past climatic regimes.

Table C.2.1: The percentage of the different clay constituents in the clay fraction in the rock formations of late Cretaceous – middle Eocene in the central Negev (from Nathan, 1966).

Formation	Rock Types	Calcium Carbonate %	Clay mineral as percentage of the total clay mineral content of rock					Number of samples
			Montmorillonite	Kaolinite	Illite	Palygorskite	Sepiolite	
Mor	Chalk, limestone with chert	80 – 100	20 – 50	–	–	50 – 80	–	16
Taqiya	Marl Chalk intercalation	40 – 60	60 – 90	–	–	0 – 30	0 – 10	93
	Marl	30 – 70	50 – 80	20 – 50	0 – 10	–	–	88
Ghareb	Chalk	70 – 90	80 – 100	0 – 20	tr.	–	–	18
	Marl	30 – 70	50 – 70	20 – 40	0 – 10	–	–	25
	Bituminous marl	40 – 90	60 – 100	0 – 35	0 – 5	–	–	23
Mishash	Main phosphate	Usually small but very variable	100	–	–	–	–	4
	Silicified chert							1
	Brecciated chert							
	Porcellanite and chert		95 – 100	0 – 5	tr.	–	–	14

Table C.2.2: Mineral Composition of Clays in some Desert Soils

Soil Type & Landform	Region; Location	Soil Horizon	Depth, cm	Kaolinite	Montmorillonite	Illite	P.
Reg Soil, Holocene; Alluvial Terrace	Dead Sea — Nahal Ze'elim	AC		****	****	—	
		BC		****	****	—	
Reg Soil, Pleistocene; Alluvial Surface	Eastern Sinai — Wadi Mukeibila	B_{ca}	6-20	*****	n.d.	n.d.	
Reg Soil, Pleistocene; Alluvial Surface	Eastern Sinai — Wadi Sa'ada	B_1	8–30	***	****	**	
		C_1	60–70	***	****	**	
Reg Soil, Pleistocene; Alluvial Surface	Southern Negev — Nahal Paran	A_v	0–3	***	****	—	
		BC_1	3-13	***	****	—	
		C_2	13–42	***	****	*	
Reg Soil; Tertiary Surface	Northern Negev — Zin Valley	BC	15–40	***	****	*	
		B_{bcs}	40–150	***	****	*	
Reg Soil, Pleistocene; Talus Slope	Eastern Sinai — Bir Sa'al	B_t	10–25	***	***	**	
Reg Soil, Pleistocene; Talus Slope	Eastern Sinai — Siket Niqbein	B_t	10–15	*****	***	***	
Hammada Soil	Central Negev — Mount Saggi	C_{2cs}	30–40	**	**	—	
Takyr Soil; Playa	Southern Negev — Qa En Naqb	A_1	0–10	*****	n.d.	n.d.	
		C_{1cs}	20–50	*****	n.d.	n.d.	
		C_2	50–110	*****	n.d.	n.d.	
Solonchak Soil; Sabkha	Eastern Sinai — Bir Sweir	$C_{1sa,cs}$	2–30	*****	*	n.d.	
		$C_{2cs,sa}$	30–55	*****	*	n.d.	
Calcic Paleosol; Alluvial Terrace	Western Negev — Nahal Kadesh Barne'a	B_b		***	****	**	
Fossil Terra Rossa	Central Negev — Mount Horsha	B_b		****	****	—	

Legend

*****	very abundant
****	abundant
***	moderate
**	minor
*	traces
n.d.	no data

Soils

te	Montmorillonite	Illite	Palygorskite	Quartz	Present Climate
	••••			•••	Extremely Arid
	••••		•	•••	
	n.d	n.d.	n.d.	n.d.	Extremely Arid
	••••	••		n.d.	Extremely Arid
	••••	••		•••	
	••••			••	Extremely Arid
	••••		—	•••	
	••••	•	—	••••	
	••••	•	••	•••	Extremely Arid
	••••	•	••	•••	
	•••	••	—	••	Extremely Arid
	•••	•••	—	••	Extermely Arid
	••		—	•••••	Arid
	n.d.	n.d.	—	•••	Extremely Arid
	n.d.	n.d.	—	•••	
	n.d.	n.d.	—	—	
	•	n.d.	—	•••	Extremely Arid
	•	n.d.		n.d.	
	••••	••	—	••	Extremely Arid
	••••	—	—	••••	Arid

C.3 SALTS — COMPOSITION AND DISTRIBUTION

Introduction

Salts in most desert terrains are intrusive materials. They are derived from airborne sources (Ericksson, 1958; Yaalon, 1963; Yaalon and Ganor, 1968; Yaalon and Lomas, 1970). Chlorides and gypsum are frequently encountered in aridic soils in the Middle East whereas $CaCO_3$ is typical to desert soils in some other areas (e.g. in the southwestern United States). In some cases dissolved carbonates from parent materials are later precipitated within the soil profile. This may have occurred in loessial soils of the northwestern Negev.

The introduction of salts into the soil is accomplished with the penetration of rainwater carrying solutes and dust. The distribution of salts in the developing soils is related to multiple rainfall events having different magnitudes and frequencies and a highly variable salt content. Several factors affect salt composition and distribution in the soil:

1. Site characteristics, such as topographic slope, catchment relations to adjacent sites, and surficial roughness.
2. Parent material and soil characteristics, such as texture, structure, porosity, and permeability.
3. The sources of salts: marine, continental, playas, bedrock exposures, and *in-situ* parent material.
4. Rainfall and dustfall characteristics: composition, amounts, durations, intensities, intervals between salt-introducing events.
5. Rates of evolution of terrain/soil properties and the interactions and feedbacks between these properties. These rates are not constant even under unchanging climatic conditions. The rates vary with different soil properties. (Birkeland, 1974).
6. Differential solubility and salt movement in an evaporating and precipitating environment.

Thus, the composition and distribution of salts in desert soils is complex, and depends upon different varying factors. Many sites of salt accumulation have undergone climatic changes throughout the Quarternary. Even young soils have developed during different climatic regimes of the Holocene period (Horowitz, 1979; Goldberg, 1981; Gerson, 1982).

Salts and gypsum are precipitated close to the surface, especially in terrains under a moderately arid to extremely arid climate, where the mean annual precipitation is lower than 250 mm. In Israel, on the flat lying to gently sloping terrains, 280mm/yr isohyet appears to be a generalised dividing line between the saline desert soils and the more calcic soils of the semi-arid environment (Dan & Yaalon, 1982). Generally, it appears that the degree of salinity increases with climatic aridity. Under the more arid climates the thickness of the saline soil profile definitely decreases. The most gypsiferous and saline soils are the Solonchaks in playas, or sabkhas along the coast, and Reg soils of the desert gravelly plains (Dan et al., 1982). Salts and gypsum accumulate uninterruptedly in soils on gently sloping or flat geomorphic surfaces. Sloping, better drained or eroding terrains, are less saline. A typical location for the accumulation of salts and gypsum is the colluvial mantle at the base of relatively well drained rocky hillslopes (Arzi, 1981; Wieder et al., 1985).

The following descriptions and discussions deal with salts and gypsum content and distribution in the non-gravelly (sand-silt-clay) fractions of desert soils. It should be born in mind that the percentage of salts is approximate, whereas the electrical conductivity (EC) measures are rather accurate.

Loessial Soils And Loessial Serosems

The salinity of loessial soils was examined in two environments: the northwestern Negev, currently under a moderately arid or semi-arid climate and the central Negev, which is under an arid climate.

A. The northwestern Negev and the Jordan Valley (figures C.3.1; C.3.22A):

1. Salinity of loessial soils is low (<3.5 mmho/cm; ususally 0.5–1.0 mmho/cm).

2. The salts are concentrated in the soil horisons usually deeper than 80 cm below surface.

3. Sometimes the A horison is somewhat more saline than the B horison.

B. The central Negev maintains a different pattern, which is typical of loessial Serosems (figures C.3.2,C.3.22A):

1. Higher salinity($\leq$40mmho/cm).

2. Salts are concentrated in the lower B and upper C horisons, usually between 20 and 80 cm below the surface.

3. There are lower salt concentrations in the A, upper B and lower C horisons.

Generally, the loessial Serosems are about ten times more saline than the loessial soils of the northwestern Negev and the peak in the salinity in the former is found at shallower depth (20–80 cm) than that in the latter (50–100 cm).

Takyr Soils

The salt and gypsum accumulation is generally similar (figures C.3.3, C.3.22G). They both increase with depth until an approximate constant amount is reached (2.0–3.5% of salts and 6–10%. of gypsum). This was observed in the clayey Takyr soils of Qa En-Naqb (a closed basin, west of Elat, which is inundated occasionally, once in 1–3 years).

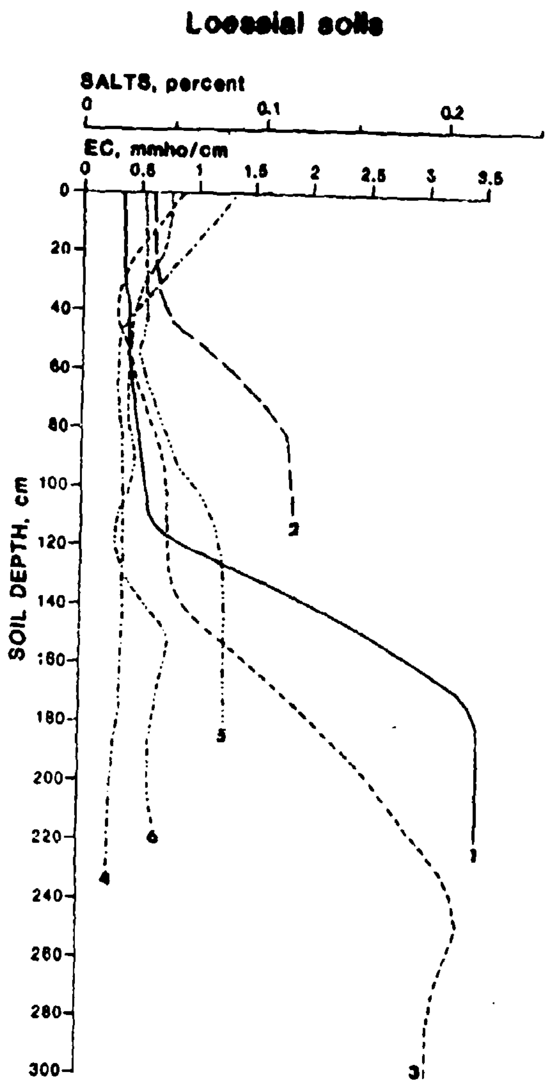
Takyr soils may develop in basins which are not completely closed but have impeded drainage. Such a case exists in the Shaharut Valley in the southern Negev, where the soils are less saline and gypsiferous, with 0.1–0.2% salts and gypsum (fig. C.3.3).

Generally, the Takyr soils are more leached than the Solonchak soils since there is no permanent water table close to the surface and thus water movement is not entirely restricted. Rates of silt and clay deposition are far higher than that of salts and gypsum precipitation. As in other aridic soils of the extreme desert (such as Reg Soils) the gypsum content is higher than salt content, with ratios around 3:1.

Solonchak Soils

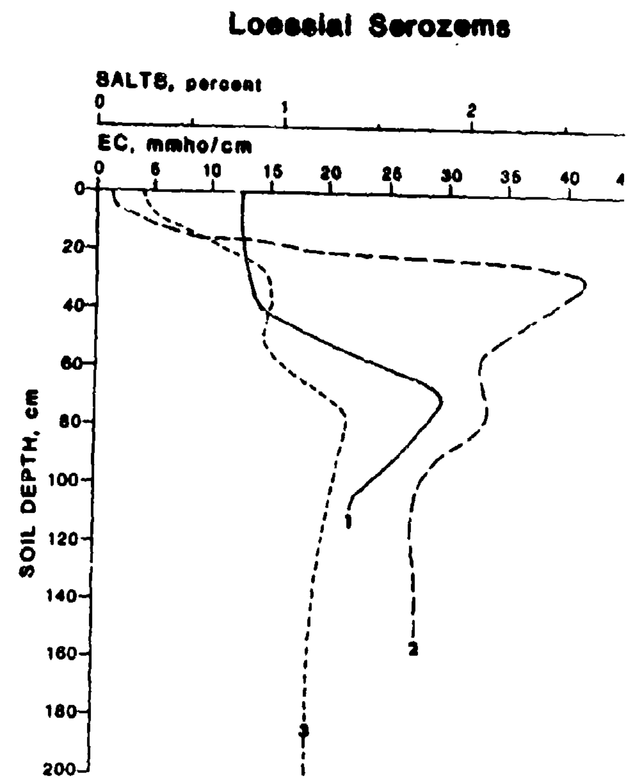
The distribution and content of salts and gypsum in Solonchak soils are highly diversified. However, several general trends are worthy of emphasis (figures C.3.4, C.3.22D):

1. Salts and gypsum increase with depth, as is the case with Sabkha soils in eastern Sinai.



1. Jordan Valley
2. North Western Negev
3-6. Western Negev

Figure C.3.1 The content of salts in Loessial soils of the Jordan Valley, western and northwestern Negev.



1,2. Sde Boker
3. Be'er Sheva

Figure C.3.2 The content of salts in Loessial Serozems, western Negev.

Takyr soils

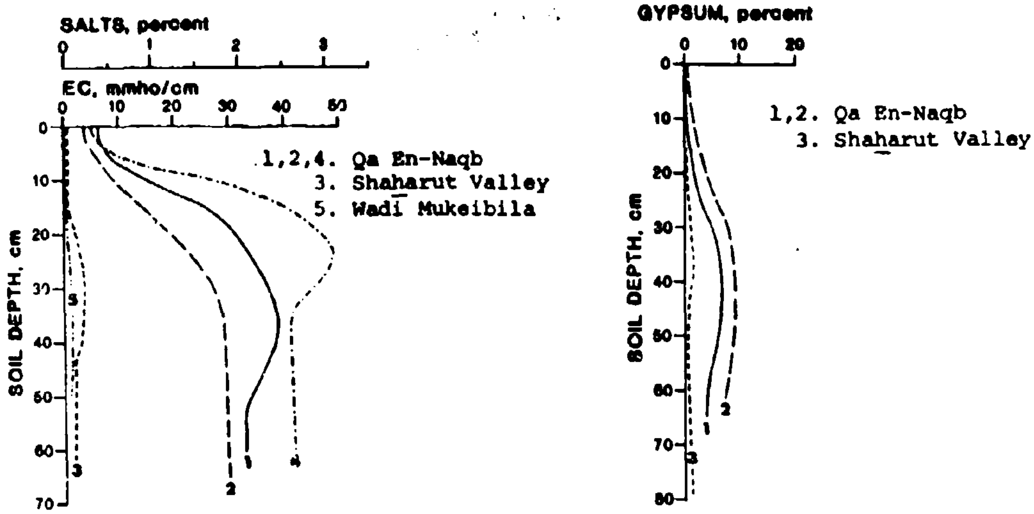


Figure C.3.3 The content of salts and gypsum in Takyr soils in the southern Negev and eastern Sinai.

Solonchak soils

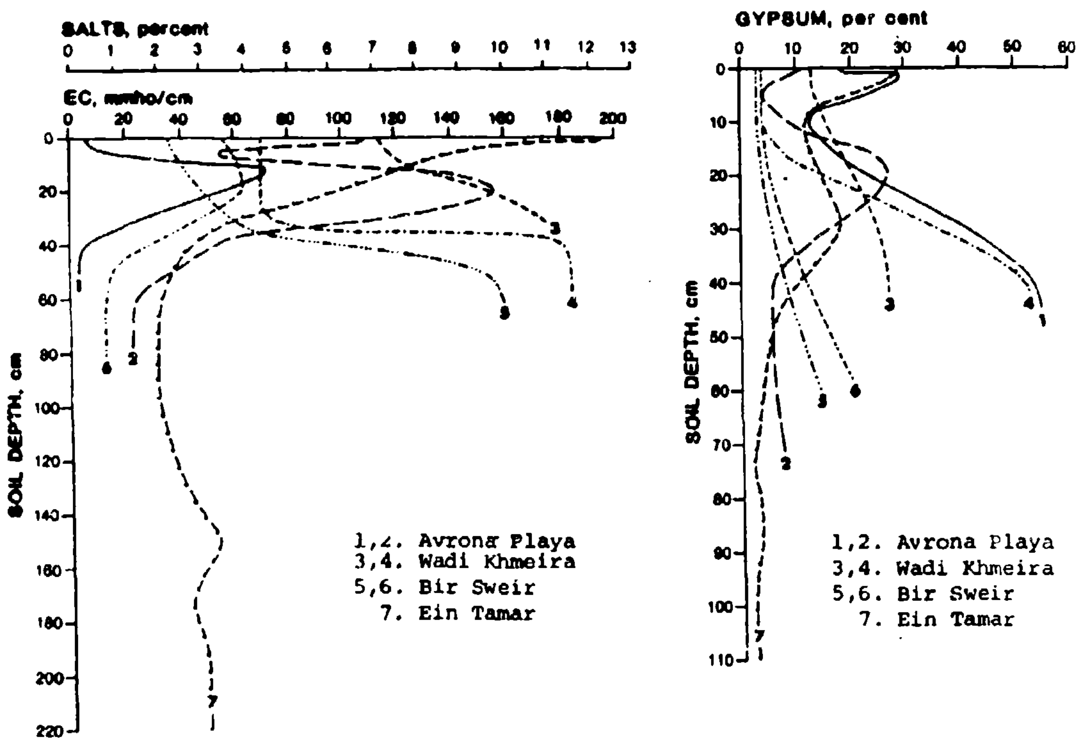


Figure C.3.4 The content of salts and gypsum in Solonchak soils in the Arava valley and eastern Sinai.

2. There is an incerease in salts and gypsum to a peak content at depths of 5-20 cm in depth, and then a decrease (sometimes to be followed by an increase to a second peak deeper down). Such is the case with the playa soils in the Arava Valley (En Avrona in the southern Arava valley and En Tamar in the northern Arava Valley).

3. Salt content close to the surface is higher in inner playa zones than in outer playa zones.

4. Salt content is usually higher with depth in coastal Sabkhas than in inland playas.

5. Trends of gypsum accumulation do not characterise the environment as well as those of salts.

6. Gypsum content is usually higher than that of salts; the ratio ranges between 1:1 to 4:1. This is lower than that found in Reg soils, due to impeded removal of the more soluble salts from the soil profile and precipitation from shallow ground/sea water.

Reg Soils

Reg soils are gravelly desert soils in which the various salts (chlorides, sulfates, carbonates) accumulate in the fine earth matrix. They do not show appreciable leaching effects, especially in the early stages of their development, when runoff and surface wash are negligible. Salts accumulate in these soils until a stage of soil degradation and truncation is reached.

Reg soils in the Negev and the Sinai are primarily gypsiferous and saline. Calcic Reg soils are not at all abundant. NaCl is predominant among the chloridic salts. Less abundant are $CaCl_2$ and $MgCl_2$ salts.

Since it is difficult to date non-calcic Reg soils, we shall resort to rather general age groups for the Negev and the Sinai. These are assigned according to the age of the alluvial surfaces on which the soils have formed: Holocene, Pleistocene, or Tertiary. However, since the soils which developed on the older surfaces may be quite old and polygenetic, one should treat the assigned ages with caution.

Reg Soils On Holocene Surfaces

Several trends are evident from our study (figures C.3.5-7; C.3.22C):

1. An increase of gypsum and salt content with depth.

2. In most soil profiles, there is a decrease of gypsum and salt content from the A to the B horizon and then a definite increase to a maximum in the lower C horizon.

3. In some soil profiles there is an increase to peak amounts at a depth of 5-10 cm and then a moderate decrease with depth (fig. C.3.6).

4. Gypsum content is usually very low in the A horizon. Gypsum usually increases with depth at higher rates than that of other salts.

5. Gypsum content is usually far higher than that of salts. The ratios range between 3:1 and 10:1 and become higher with depth.

6. The gypsic/saline soil profile usualy reaches some 40-50 cm in depth. Only in highly pervious parent materials (such as sieve deposits) does salinity reach 60-80 cm.

7. There is a definite change in the accumulation rate of gypsum and salts with time (figures C.3.6,7).

Holocene Reg soils

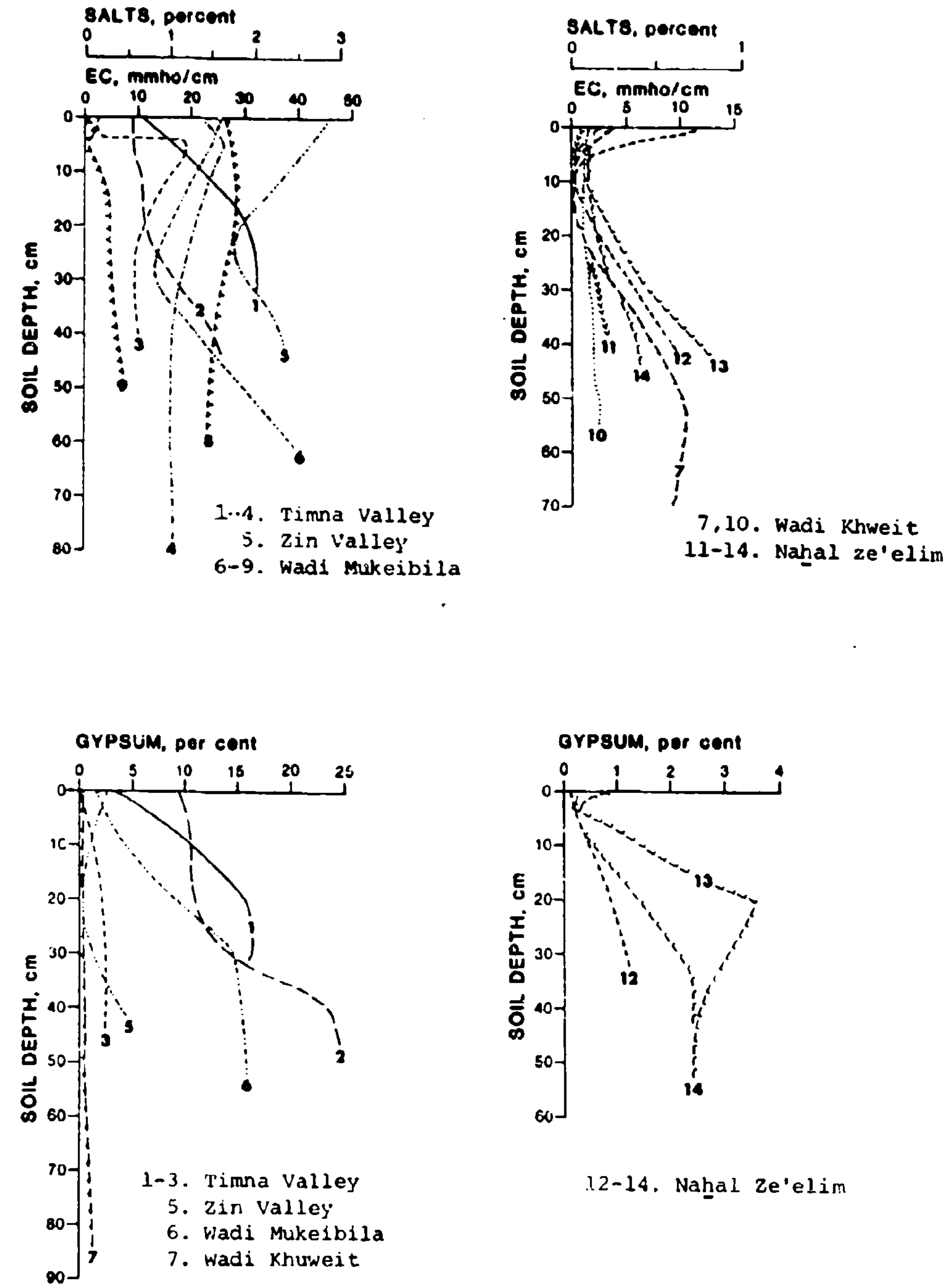


Figure C.3.5 The content of salts and gypsum in the fine earth fraction of some Holocene Reg soils, in the Dead Sea region, Arava Valley, Zin Valley and eastern Sinai.

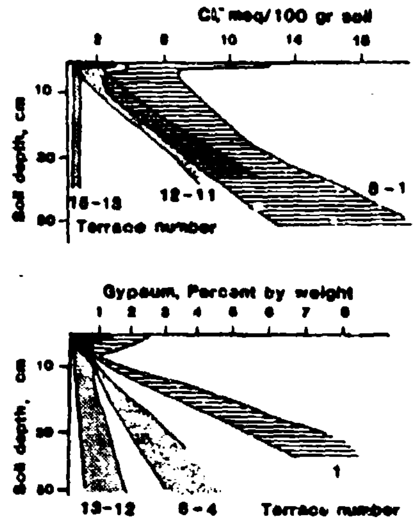


Figure C.3.6 Variation of gypsum and chlorides with depth, in a sequence of Holocene Reg soils (terrace no. 1 – oldest; terrace no.15 – youngest), Nahal Ze'elim (Dead Sea).

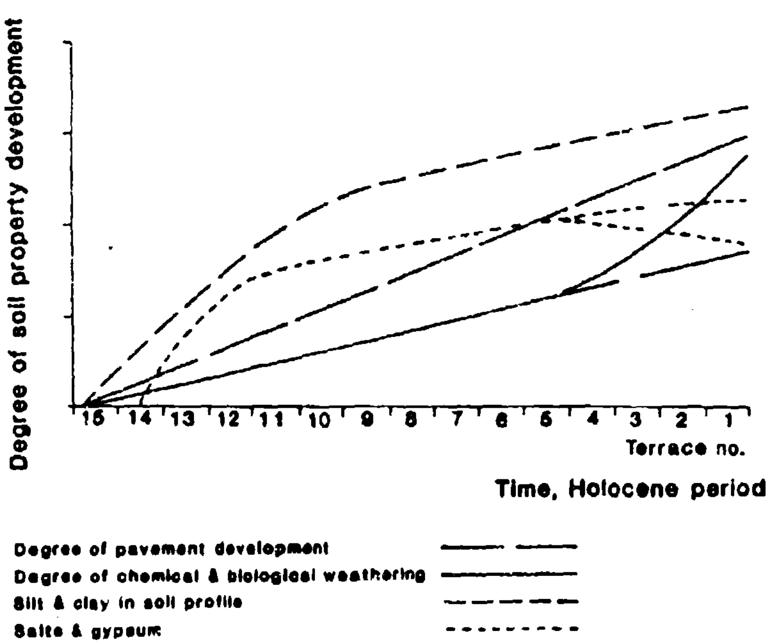


Figure C.3.7 The evolution of some properties of Holocene Reg soils with time (terrace no.1 – oldest; terrace no.15 – youngest), Nahal Ze'elim (Dead Sea).

Some conclusions are as follows:

1. There is no good leaching of the upper soil horizon.

2. There is a diversity in the leaching and precipitation of the different salts. With depth, gypsum accumulates at higher rates than the more soluble salts. Being of much lower solubility, gypsum will be concentrated at lower depths due to two types of processes: (a) rainstorms of high amounts and duration may dissolve gypsum from the upper horizons and precipitate it in the lower ones; (b) the combination of capillary rise and evaporation may carry the more soluble salts into the upper horizons and precipitate them there. This may be especially true in the upper horizons which are richer in fines (silts and clays) than the lower horizons (see chapter C.1). In sieve deposits, where initial porosity and pore size are the greatest, there is no differentation of ratios throughout the profile since water does not migrate upward through a fine grained matrix.

3. There is a decrease in the rates of gypsum and salt accumultation with time. This is related to a change of the hydrologic regime as more fines are added to the soil profile (see chapter C.1)

4. There maybe some loss of the more soluble salts due to leaching during extreme rainfall events, especialy in the initial stages of soil development.

5. We have found only one soil profile (in the Zin Valley, central Negev) in which the A horizon is highly gypsic. A possible reason for this situation may be soil profile truncation by erosion. Also, in environments where the original parent material has a high clay/silt content, soils may show the same trend.

6. Generally, we could not clearly differentiate between trends in gypsum and salt composition and distribution in Reg soils having some difference in their gravelly parent material. However, a hint is obtained by the comparative study of soils developed on gravel-bars and swales on alluvial terraces. The former are more saline than the latter; some of the water from the bars drain into the swales and soils there are slightly less saline.

Reg Soils On Pleistocene (and older) Surfaces

These soils have undergone salinization for long periods of time and have certainly been affected by climatic changes. They are old and polygenetic; many of them are relict paleosols. The lack of well established dates and the polygenesis of these soils preclude correlation of the studied profiles by quantitative analysis. Still, several generalizations may be presented (fig. C.3.8):

1. An increase of gypsum and salts with depth.

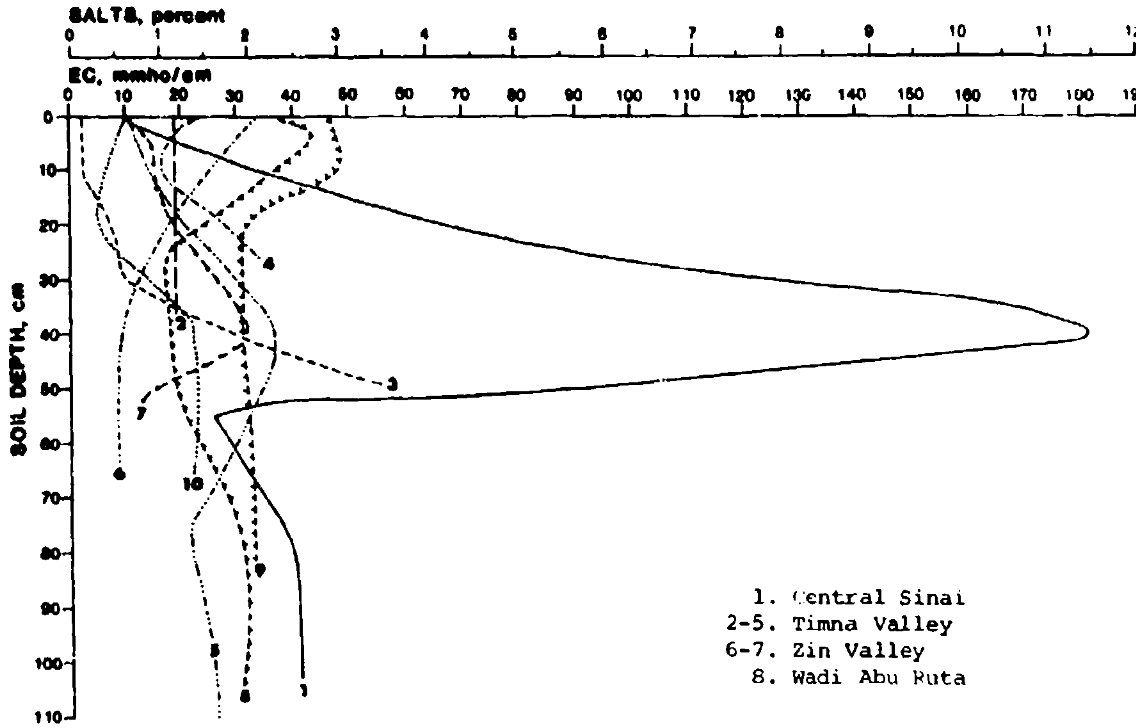
2. Surficial horizons contain more salts than gypsum, but the ratio is reversed down-profile, where there is a higher gypsum than salt content.

3. There are three different trends of change in gypsum and salt content with depth: (a) an increase with depth; (b) an increase and then a decrease with depth; (c) the B horizon contains lower concentrations of gypsum or salt than the A and C horizons.

4. Salt content is usually less than 2%, while gypsum ranges between 10% and 20% by weight. The gypsum:salt ratios range between 2:1 and 10:1. In the older soils, the ratios are 5:1 to 10:1.

5. Some Pleistocene Reg soils reach levels of salinity which are not observed in any Holocene Reg soils.

Pleistocene Reg soils



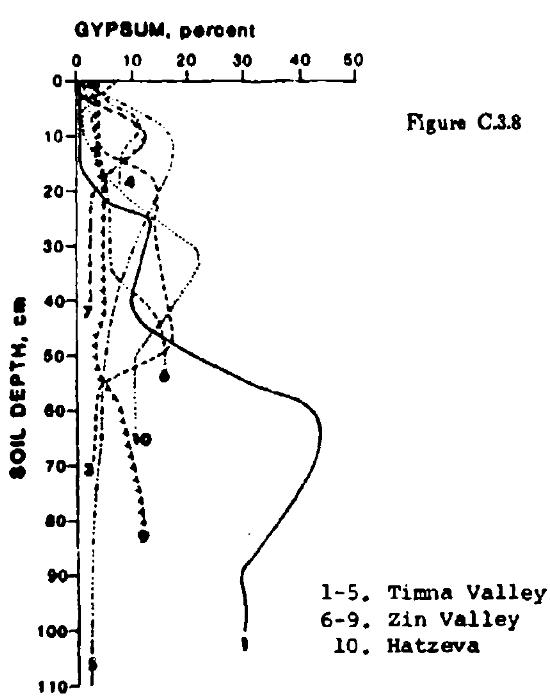


Figure C.3.8 The content of salts and gypsum in the fine earth fraction of Reg soils on Pleistocene alluvial surfaces in the Negev and eastern Sinai. Curve no.1 is typical to Reg soils on early Late Pleistocene and older alluvial surfaces (see plate 13E).

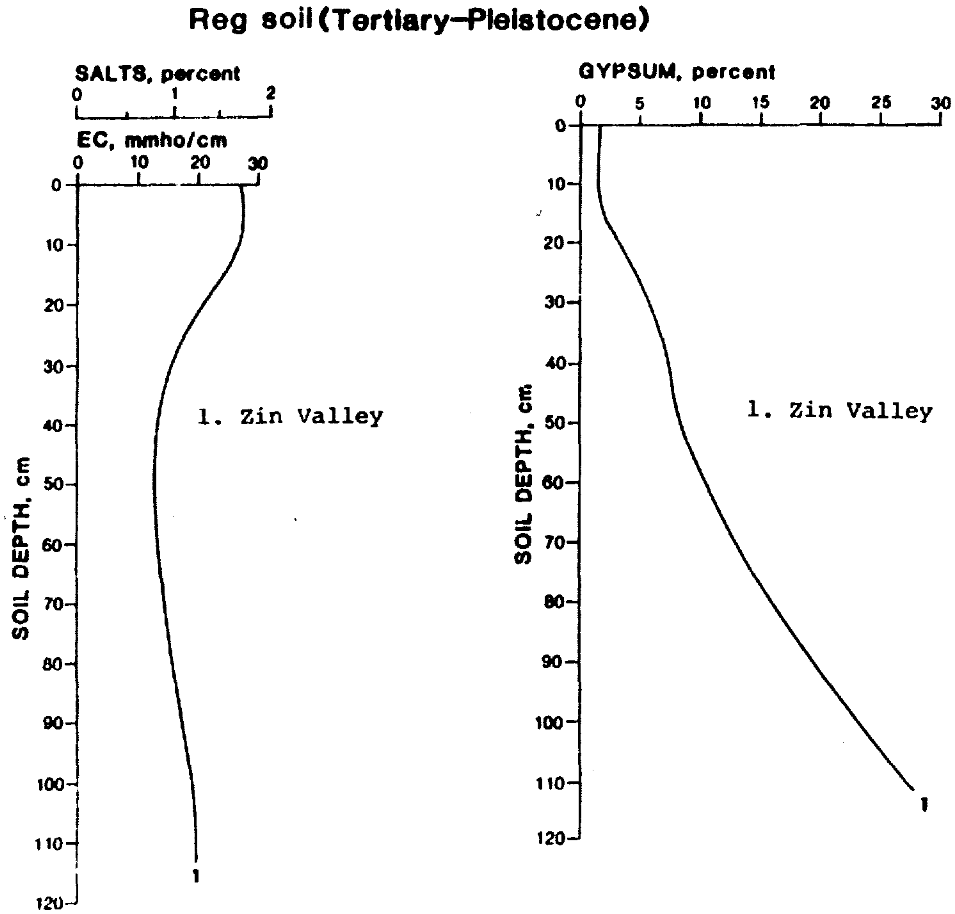


Figure C.3.9 The content of salts and gypsum in a thick and old gravel-free profile of a Reg soil, on a very old alluvial surface, above the Zin valley, northern Negev.

Lektion 8

Präpositionen mit Dativ oder Akkusativ

wo? Dativ wohin? Akkusativ wann? Dativ

Lokal: Akkusativ **Dativ**

an: Ich hänge das Bild an die Wand.
Das Bild hängt an der Wand.

in: Wir gehen jetzt ins Haus.
Wir sind im Haus.

auf: Sie stellt das Glas auf den Tisch.
Das Glas steht auf dem Tisch.

hinter: Er geht hinter das Haus.
Er wartet hinter dem Haus.

vor: Er fährt vor das Haus.
Er parkt vor dem Garten.

neben: Ich setze mich neben meinen Freund.
Ich sitze neben meinem Freund.

über: Wir fahren über den Fluss.
Über dem Fluss ist eine Brücke.

unter: Er läuft unter das Dach.
Sie sitzen unter der Lampe.

zwischen: Sie wirft den Ball zwischen die Bücher.
Der Ball liegt zwischen den Büchern.

an dem = am	an das = ans	in das = ins
in dem = im	vor dem = vorm	vor das = vors

Temporal: wann? (Dativ)

an: An dem Tag bin ich zu Haus.

in: In diesem Monat muss er viele Bücher kaufen.

vor: Vor dem Fest kann er nicht kommen.

zwischen: Er arbeitet zwischen den Feiertagen nicht viel.

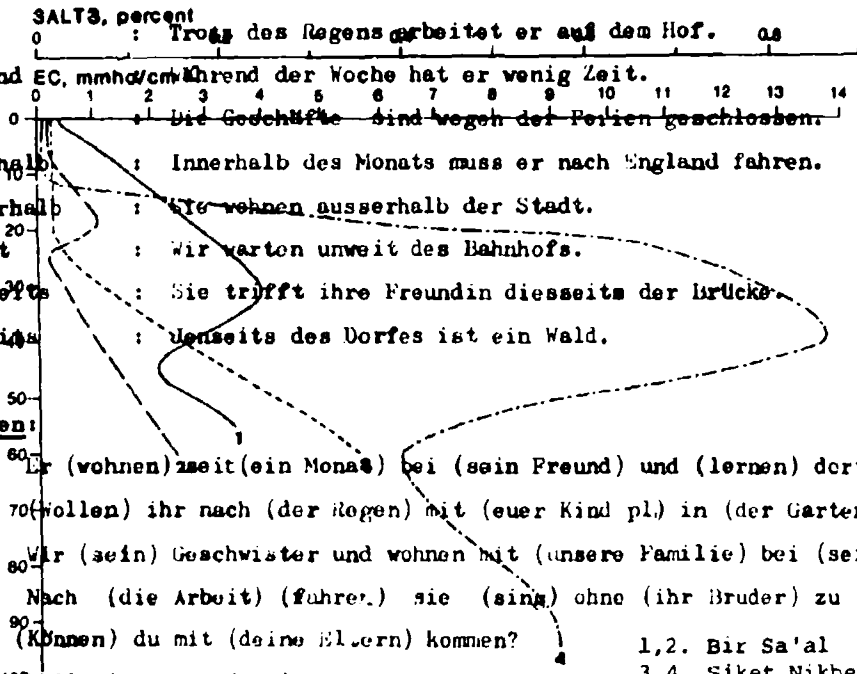
Präpositionen mit dem Genitiv

statt (anstatt): Er kommt statt seines Freundes zur Vorlesung.
trotz : Trotz des Regens arbeitet er auf dem Hof.
während : Während der Woche hat er wenig Zeit.
wegen : Die Geschäfte sind wegen der Ferien geschlossen.
innerhalb : Innerhalb des Monats muss er nach England fahren.
ausserhalb : Sie wohnen ausserhalb der Stadt.
unweit : Wir warten unweit des Bahnhofs.
diesseits : Sie trifft ihre Freundin diesseits der Brücke.
jenseits : Jenseits des Dorfes ist ein Wald.

Übungen:

1) Er (wohnen) seit (ein Monat) bei (sein Freund) und (lernen) dort.
2) (Wollen) ihr nach (der Regen) mit (euer Kind pl.) in (der Garten) gehen?
3) Wir (sein) Geschwister und wohnen mit (unsere Familie) bei (seine Tante).
4) Nach (die Arbeit) (fahren) sie (sing) ohne (ihr Bruder) zu (die Prüfung).
5) (Können) du mit (deine Eltern) kommen?
6) (Wollen) du mit (ich) um (der Häuserblock) spazierengehen?
7) Sie (sing.) (gehen) ohne (ihr Mantel) durch (der Park).
8) (können) ihr mit (euer Kind pl) zu (sein Vortrag) kommen?
9) Für (der Rest) (die Woche) (fahren) er nach Haus.
10) (kaufen) du statt (der Teppich) (ein [illegible]) für (er)?
11) Diesseits (das Gebirge) gibt es (ein Fluss).
12) Gegen Abend (treffen) er (der Sohn)(sein Freund).
13) (Spielen) du mit (ich) gegen (er)?
14) Unweit (sein Haus) ist die Haltestelle.
15) Wegen (das Wetter)(wollen) er nicht kommen.
16) Die Eltern machen mit (ihre Kinder)(ein Ausflug).

... on Pleistocene talus slopes



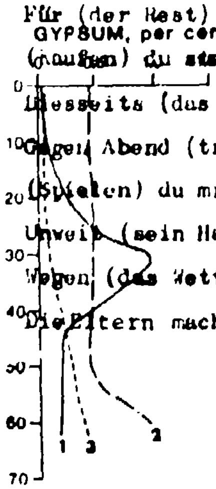


Figure C.3.10 The content of salts and gypsum in the fine earth fraction of ... gravelly talus slopes, in the southern Sinai.

TABLE C.3.1 SALT AND GYPSUM CONTENT IN CATENAS ON TALUS SLOPES (REG SOILS AND GRAVELLY REGOSOL).

Location	Pit Site	Horizon; Depth in cm	Electrical Conductivity mmho/cm	Salts Approximate Percent	Gypsum Percent
Makhtesh Ramon	upper talus	A_1 0 - 1	17.5	1.09	0.8
		C_1 1 - 30	27.3	1.71	14.8
	lower talus	A 1 - 30	2.6	0.15	2.3
		C_1 30 - 40	0.4	0.03	traces
		C_2 40+	12.2	0.75	5.7
Mount Amram	upper talus	C_1 10 - 30	15.8	0.99	1.5
		C_2 30 - 60	2.9	0.18	2.5
	center talus	5 - 12	0.3	0.02	traces
		27 - 42	0.2	0.01	traces
	lower talus	0 - 20	0.5	0.03	traces
Wadi Mukeibila	center talus	30 - 55	7.2	0.45	0.8
		75 - 90	60.7	3.79	4.4
	lower talus	40 - 60	1.2	0.08	1.8
		65 - 90	37.5	2.35	3.2
Bir Saal	center talus	A_1 0 - 1	0.4	0.03	traces
		A_2 2 - 10	1.8	0.11	traces
		B_1 15 - 25	3.3	0.21	0.4
		20 - 30	4.0	0.25	0.9
		C_1 35 - 45	2.0	0.13	0.3
		C_2 45 - 55	3.3	0.21	0.3
	lower talus	A_1 0 - 1	0.1	0.01	traces
		B_1 1 - 6	0.1	0.01	traces
		C 1[illegible] - 20	1.2	0.08	traces
		C [illegible] - 25	0.2	0.01	0.7

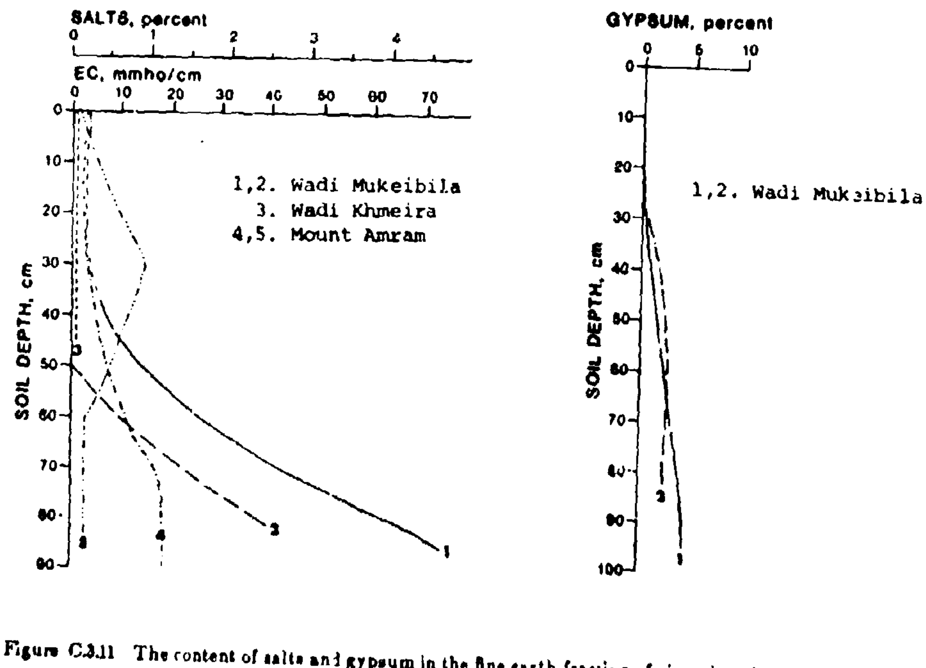


Figure C.3.11 The content of salts and gypsum in the fine earth fraction of sieve deposits on talus slopes in the Arava Valley and eastern Sinai.

6.In Reg soils on taluses and in colluvial sieve deposits the gypsum content is slightly higher than that of salts. Generally, soils on talus slopes (Reg soils, as well as soils on sieve deposits) are less saline and gypsiferous than soils on gravelly plains. They are better drained and more leached by surface wash and through-flow.

There is a trend of decreasing salinity downslope on many taluses (table C.3.1). Salt content is usually higher in soils on the upper sections of taluses then that in the soils on the middle-lower sections. A similar trend was observed with respect to gypsum content. Wash and leaching of the lower portions of the slopes by water from upslope reaches are a possible reason for the situation.

Hammada Soils

In Hammada soils one finds a high rate of increase in salts and especially gypsum with depth (figures C.3.12; C.3.22I). The greatest amounts of salts are usually in the gravel-free B horizon, whereas the gypsum content is higher at the lower horizons (≤25% in lower B and C horizons). Surficial horizons are leached, probably because of their stoniness and the slow rate of desert pavement evolution.

Stony Serosem Soils And Lithosols

Usually, these soils show an increase in salinity with depth (figures C.3.13,14; C.3.22E,H). The highest salinity is in the lower C horizon, at a depth of 50–80 cm. Such Serosem soils represent a moderately arid to arid environment and the upper horizons are leached of salts (figures C.3.14; C.3.22E). Only about 0.1% of salts and gypsum may appear. A similar trend is observed in desert Lithosols, which are generally shallower in depth (figures C.3.13; C.3.22H).

Sand Dune Soils

Sandy soils which have developed under semi-arid to arid climates in the coastal plain in southern Israel and northern Sinai are poor in salts. Salts content along the soil profile is rather constant to depths of 200 cm and more; it is usually less than 0.03% (fig. C.3.15). The relatively high permeability and the sufficient rainfall, including occasional high-quantity/intensity rainstorms, may account for this pattern.

Conclusions

It is still impossible to draw sound quantitative correlations between soil properties and environmental factors such as average annual precipitation, hillslope gradient, distance from hillcrest or asimuth of exposure. Most of the soils encountered in deserts are polygenetic in nature and many of them are still in the process of formation Yet several general conclusions may be presented:

1. There is a general increase of soil salinity with decreasing mean annual precipitation or effective moisture. This is a most generalised conclusion, which conforms with higher degree of leaching in the less arid environments and a greater contribution of eolian salts in the more arid terrains. In order to test the validity of the change of salinity with the gradient of precipitation amounts, one should use similar terrains. However, certain types of soils such as loessial soils — dominant in the semi-arid northwestern Negev — do not exist in the more arid parts of the Negev, whereas Reg soils or Solonchak soils do not show in the northwestern Negev. Some terrains are exclusive to certain environments or regions. In the loessial terrains there is an increase of salinity with climatic aridity,

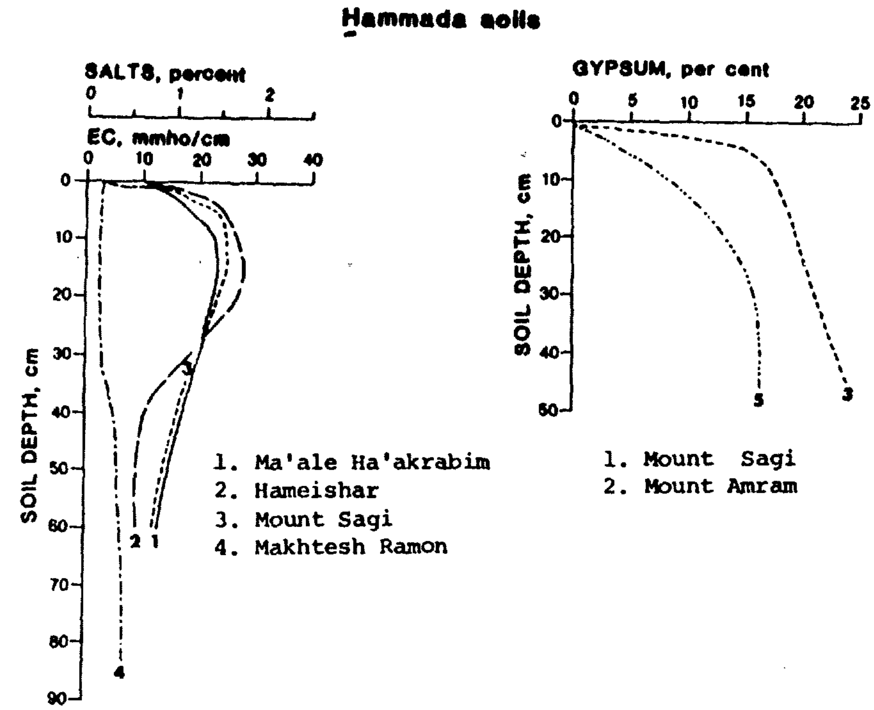


Figure C.3.12 The content of salts and gypsum in the fine earth fraction in some Hammada soils in the northeastern and central Negev.

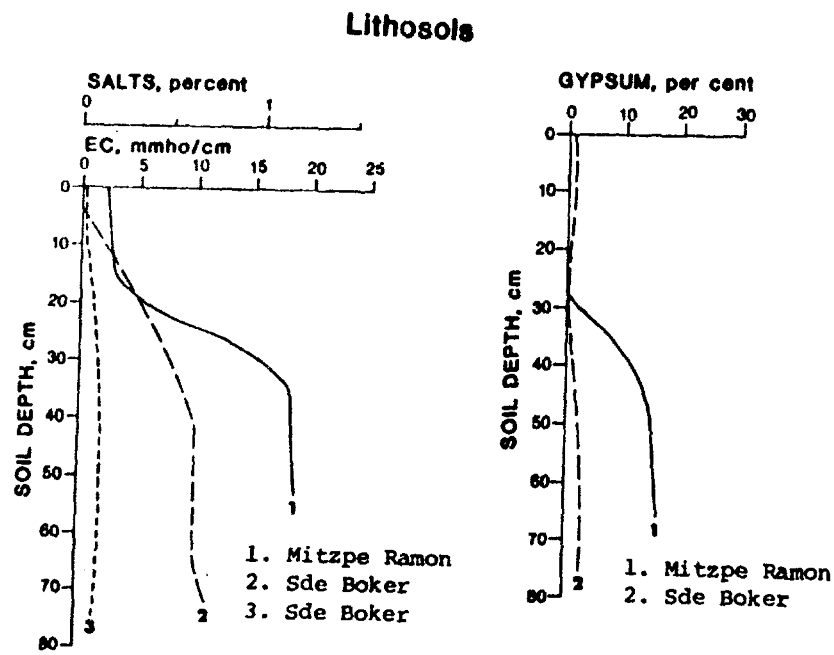


Figure C.3.13 The content of salts and gypsum in Lithosols in the northern and central Negev.

Serozem soils

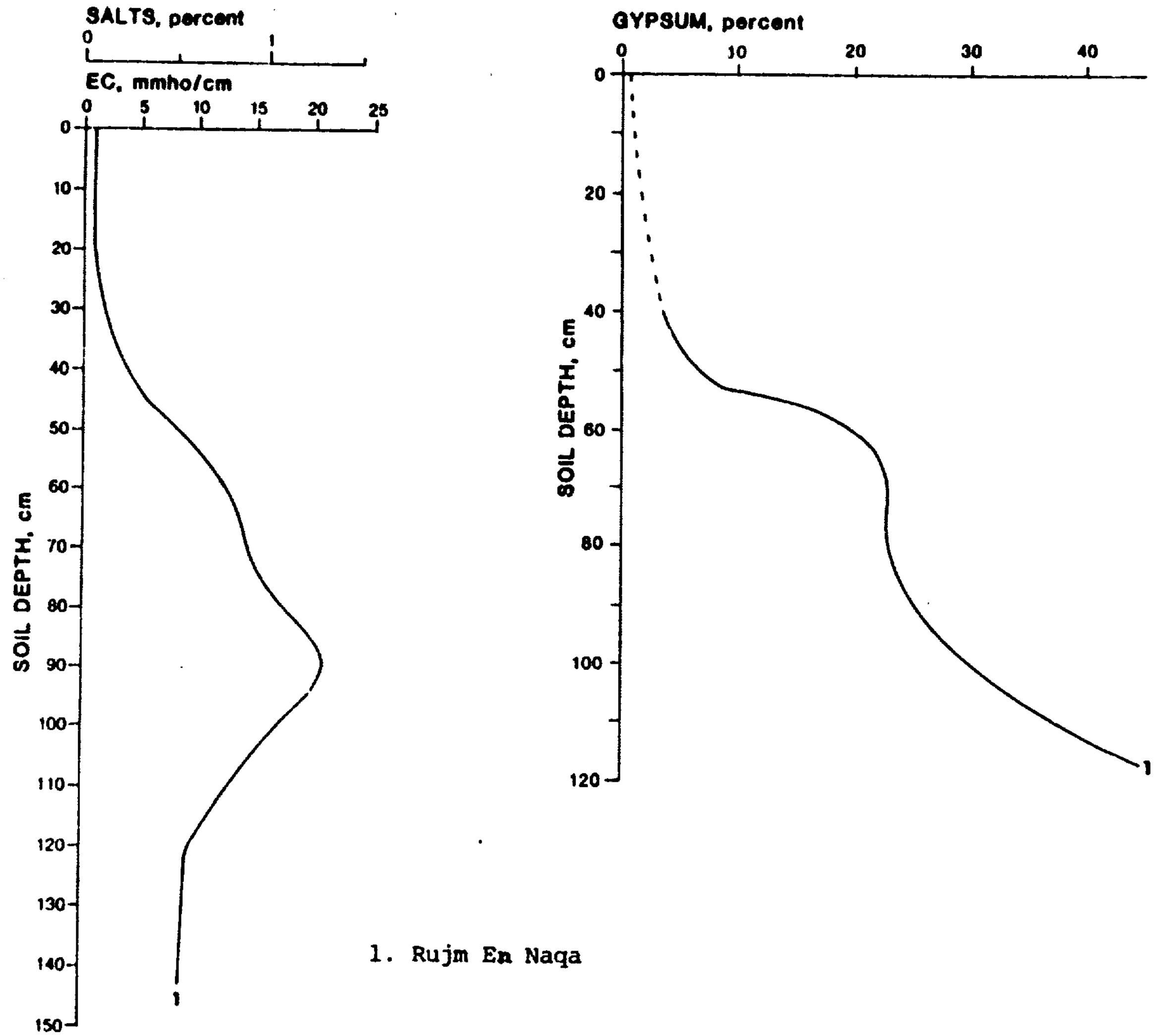
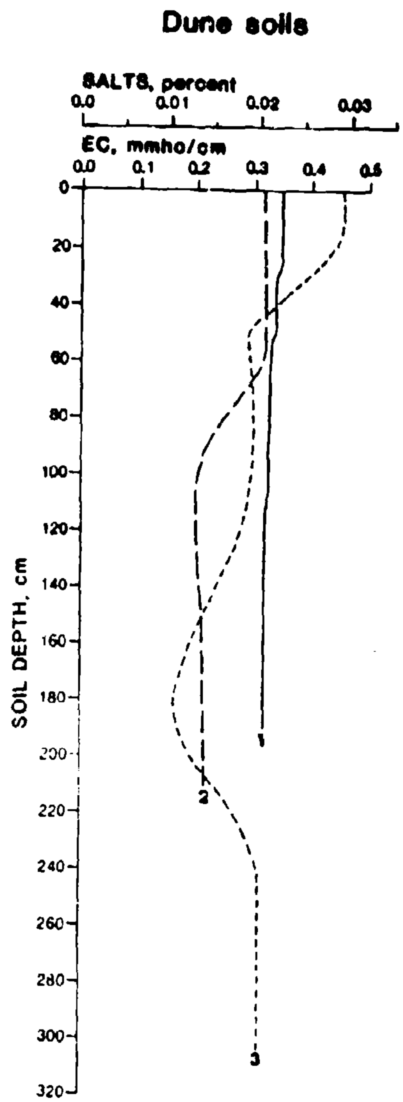


Figure C.3.14 The content of salts and gypsum in a Serozem soil in the Judean Desert.



1-3. Northwestern Negev

Figure C.3.15 The content of salts in dune soils in the northwestern Negev.

primarily through the decreasing effects of leaching and a higher trap efficiency. The end members are the non-saline loessial soils of the northwestern Negev and the loessial serosems further southeast, in the central Negev. Yet, in the Reg soils we have not traced a clear trend. Holocene as well as Pleistocene Reg soils in the extremely arid southern Negev are not definitely more saline or gypsiferous than Reg soils of comparable ages in the somewhat less arid central and northern Negev. This may be due to the fact that in a non-leaching environment high salinity values are due to somewhat greater amounts of salt carrying rainfall.

2. The distribution of salinity values through the soil profile is not uniform. There is a decrease in depth of the horison of peak salinity in the soil profile with increasing aridity, or decreasing mean annual rainfall. This trend is most clearly observed in soils on flat surfaces or gently sloping terrains. Peak salinity is found there at depth of more than 80 cm in loessial soils in the northwestern Negev, and less than 50 cm in Reg soils under extremely arid climates. A complication of this general trend arises in polygenetics soils formed under changing climatic regimes. In these one may find more than one gypsic and/or salic horisons at various depths.

3. Local conditions highly affect the amounts and distribution of the salts in the soils. Several environmental settings where local conditions are dictating characteristic salinity distributions may be noted:

(a) Highly pervious parent materials, such as gravelly sieve deposits and sand, into which salts penetrate to great depths (of more than 100 cm) and are in most cases evenly distributed. Only after such parent materials are densely impregnated by dust, the general existance of horizons of high peak salinity is clearly marked.

(b) On hillslopes one finds a clear control of drainage: colluvial mantle at the base of rocky outcrops may be leached, or salts are found at great depths, due to high runoff input from the rocky surfaces. Further downslope on a loessial colluvial cover one often finds very saline soils due to lack of effective leaching or wash (Danin, 1970; Arsi, 1981; Wieder et al., 1985). On gravelly talus slopes, where drainge and wash integrate downslope, there is higher salinity in the Reg soils on upslope (backslope) reaches than on downslope (footslope) ones.

4. The effects of local and regional sources of salts may be decisive. The highly gypsiferous nature of the soils in the Arava Valley and Makhtesh Ramon (central Negev) is augmented by gypsum derived from gypsiferous rock formations exposed upwind. Some of the saline playa deposits in the Arava Valley are carried southward by the prevailing winds onto the extremely arid terrains bordering the Gulf of Elat.

5. The rate of increase in salts and gypsum in some soils decreases with time. Reg soils show a very slow change in salinity after some 1000–3000 years. Some soils may become relict after tens of thousands of years, as may be the case of Reg and Hammada soils. Thus, soils on early Holocene and Pleistocene alluvial surfaces may show similar ranges of salinity.

6. Most desert soils in Israel and Sinai tend to have a high gypsum to salts ratio (usually ranging between 2:1 and 10:1). This fact deserves a close attention. The ratio appears to increase with the age of the soil. Old (Pleistocene) soils usually have a higher gypsum/salts ratio than Holocene soils. Several processes contribute to this trend: (a) The

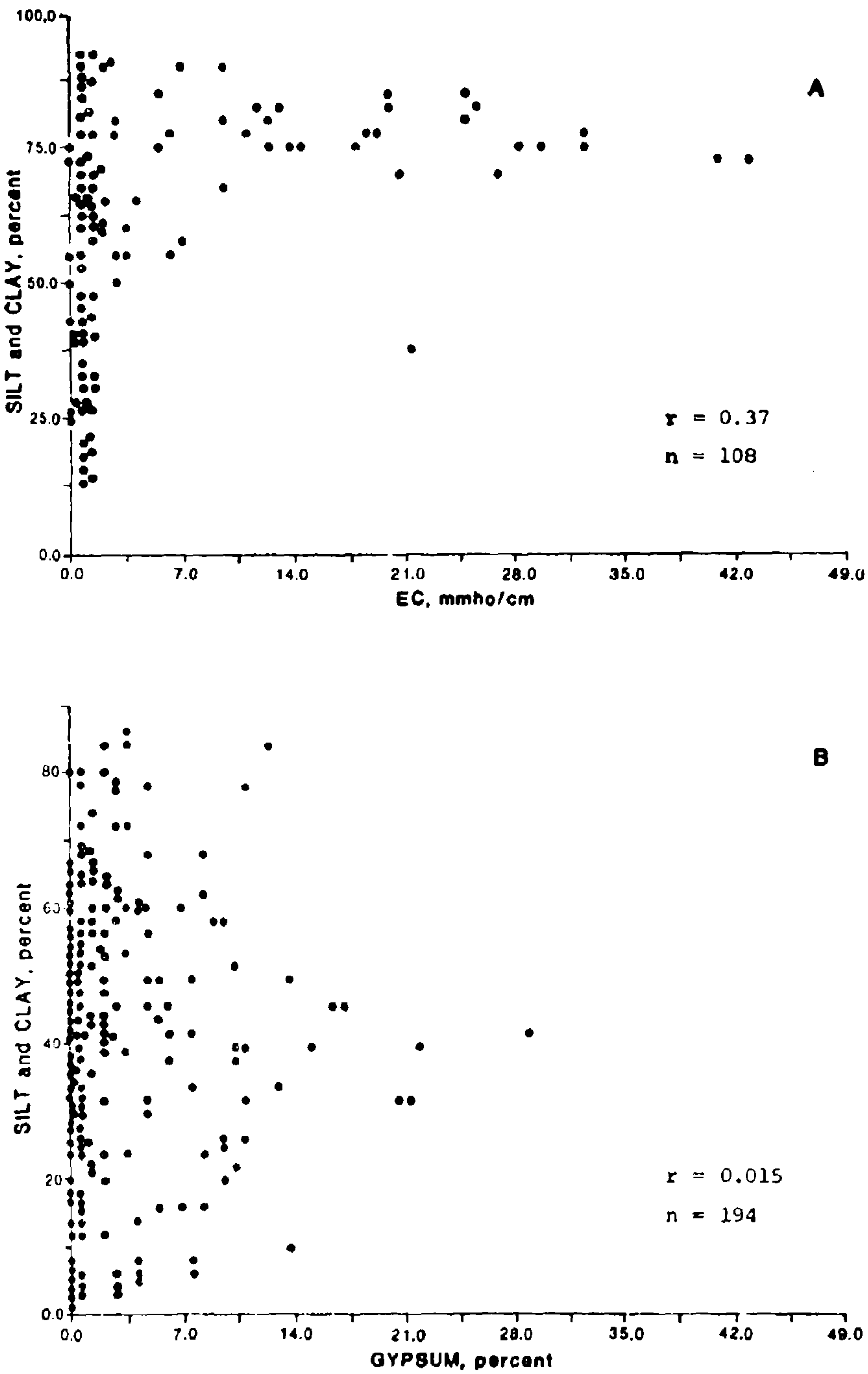


Figure C.3.17 The correlation between the content of dust (silt and clay) and salintly-expressed as electrical conductivity (EC). A. Loessial soils in the northern and northwestern Negev. B. Pleistocene Reg soils in the Negev and Sinai.

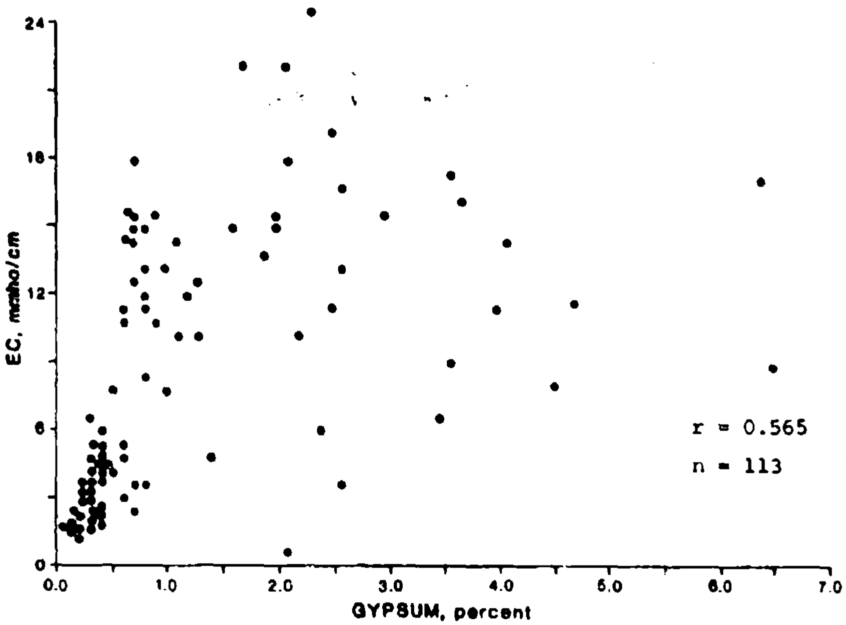


Figure C.3.16 The correlation between gypsum content and salintly, expressed as electrical conductivity (EC), in Holocene Reg soils, Nahal Ze'elim (Dead Sea).

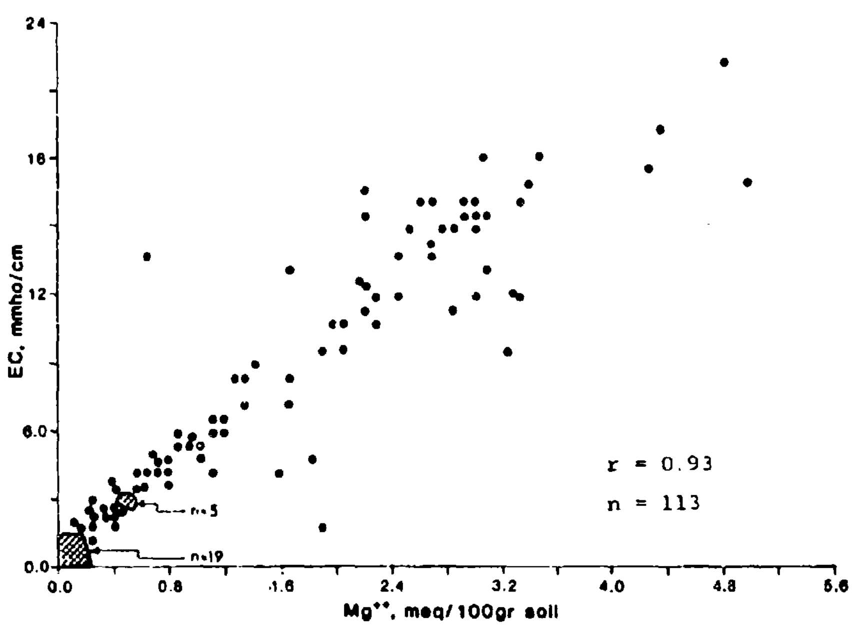


Figure C.3.18 The correlation between the electrical conductivity and Mg^{++} in soluble salts in the Holocene Reg soils of Nahal Ze'elim (Dead Sea).

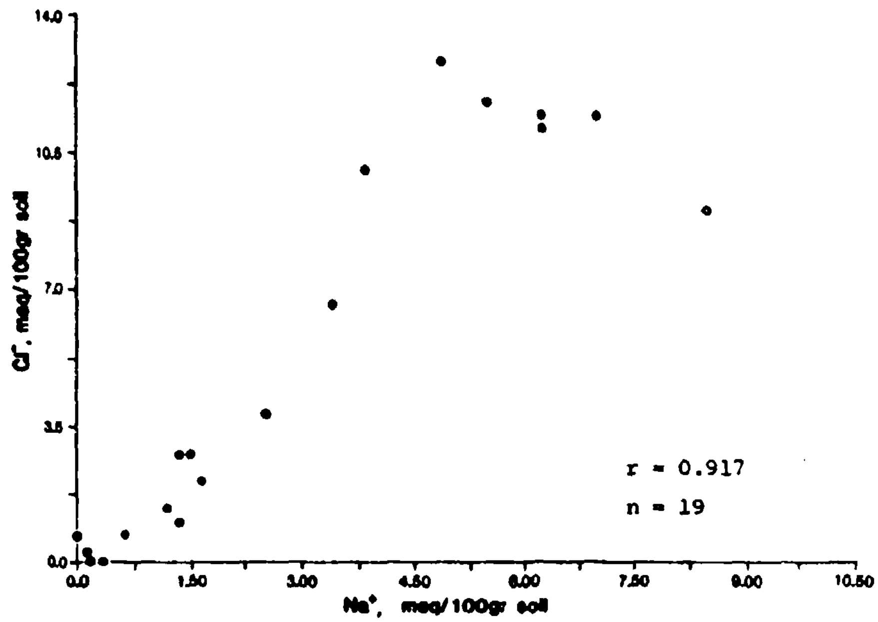


Figure C.3.19 The correlation between Na^+ and Cl^- in the soluble salts of the B horisons, in the Holocene Reg soils of Nahal Ze'elim (Dead Sea).

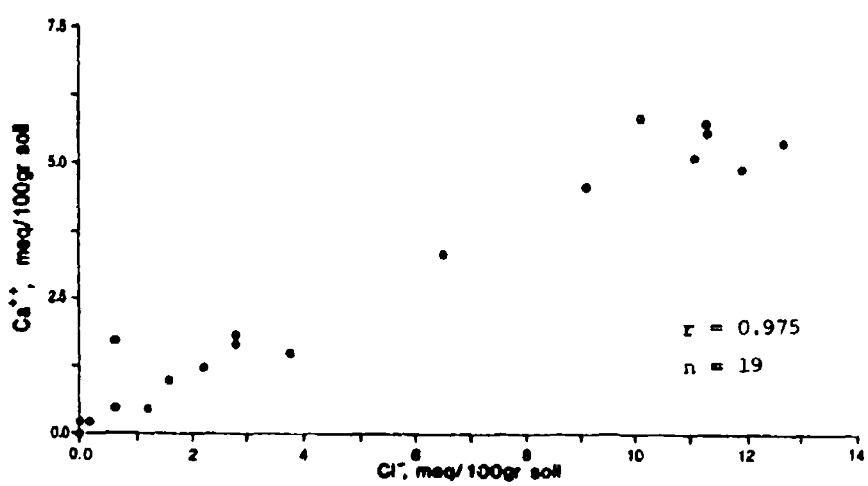


Figure C.3.20 The correlation between Cl^- and Ca^{++} in the soluble salts of the B horisons, in the Holocene Reg soils of Nahal Ze'elim (Dead Sea).

more soluble salts (chlorides) are partially leached during events of large rainfall amounts (Arkley, 1981; Dan, 1983) or wetter climatic regimes; (b) Some of the more soluble salts may rise in the soil profile during periods of desiccation after rainstorms, and are later washed by surface runoff.

7. There is no good relationship between the contents of salts and gypsum in discrete soil horizons or whole soil profiles (fig C.3.16). This is due to several reasons: (a) A very diversified hydrochemical composition of rain water of different rainstorms. (b) Differential solubility and mobility of the various salts. Leaching and capillary rise redistribute salts in the soil and remove some of the more soluble materials. (c) There is a gradual change of soil texture with time; this affects the hydraulic properties of the soil (see chapter C.1) and with it — the distribution of various salts in the soil profile. (d) Most aridisols are polygenetic; they have developed under changing climatic regimes, with varying rainfall and salt contribution patterns.

8. There is no established quantitative relationship between the amounts of salts or gyspum and the quantities of fines (silt and/or clay) in the soil (fig. C.3.17). The higher mobility of the salts through the soil is the major reason for this situation. The soils richest in fines are loessial soils and Takyr soils while the most saline soils are Solonchaks and Reg soils; in the latter two soil types the relative amounts of introduced salts versus trapped dust are high. A very general trend is that the salts/dust ratio increaces with aridity, due to decreasing leaching and low dust trapping of the soil in the more arid environment. In soils rich in fines under arid to extremly arid climates, one generally observes a retarded dust penetration while introduction of salts is still effective; such soils become more saline with time.

9. The composition of the chloridic salts in the soil was not studied in detail; however, several observations were made: (a) There is a high degree of correlation between several variables in the Holocene Reg soils: (1) Electrical conductivity and Mg^{++} content (fig. C.3.18); (2) The content of Na^{+} and Cl^{-} (fig. C.3.19); (3) The content of Ca^{++} and Cl^{-} (fig. C.3.20). Such correlations point to the rather constant overall relationships between the components of the chloridic salts. (b) There is a certain similarity between the salt composition of sea water and that of Solonchak soils in coastal Sabkhas and some young soils, such as Holocene Reg soils (fig. C.3.21) and A horizons in some other aridisols. (c) Most older soils and soil horizons are different in their salt composition from both sea water and average rain water.

10. Calcic soils, in which calcium carbonate is a major precipitate, are found mainly in the less arid environments — the northern and northwestern Negev. Such soils are encountered also as paleosols in areas where gypsic and salic soils are being formed at present, and were observed in many sites in the arid and extremely arid parts of the Negev and the Sinai.

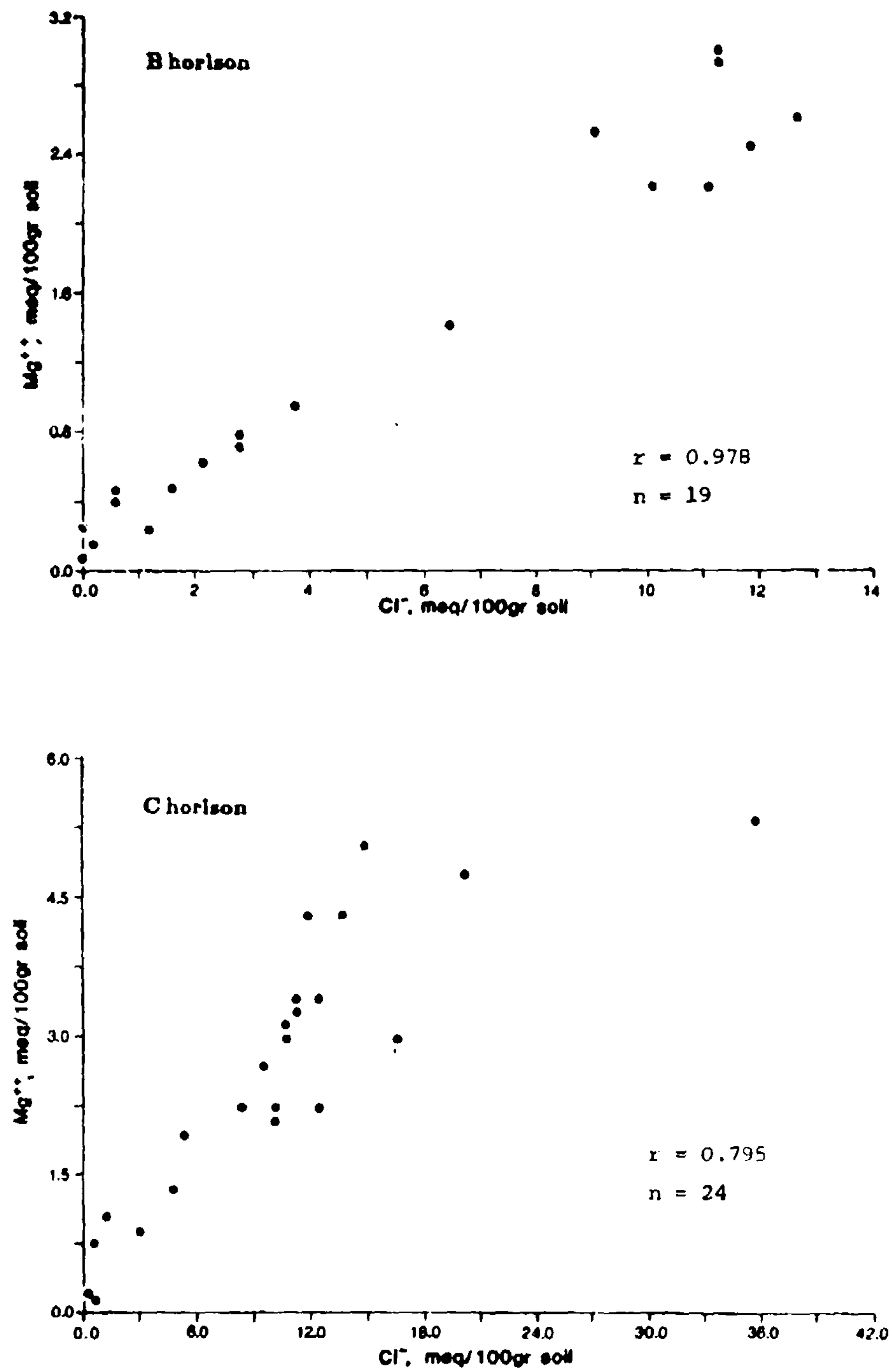


Figure C.3.21. The correlation between Mg^{++} and Cl^{-} in the soluble salts of the B and C horisons, in the Holocene Reg soils of Naḥal Ze'elim (Dead Sea). Note that the ratio between the two variables is about 1:5, similar to that of sea water.

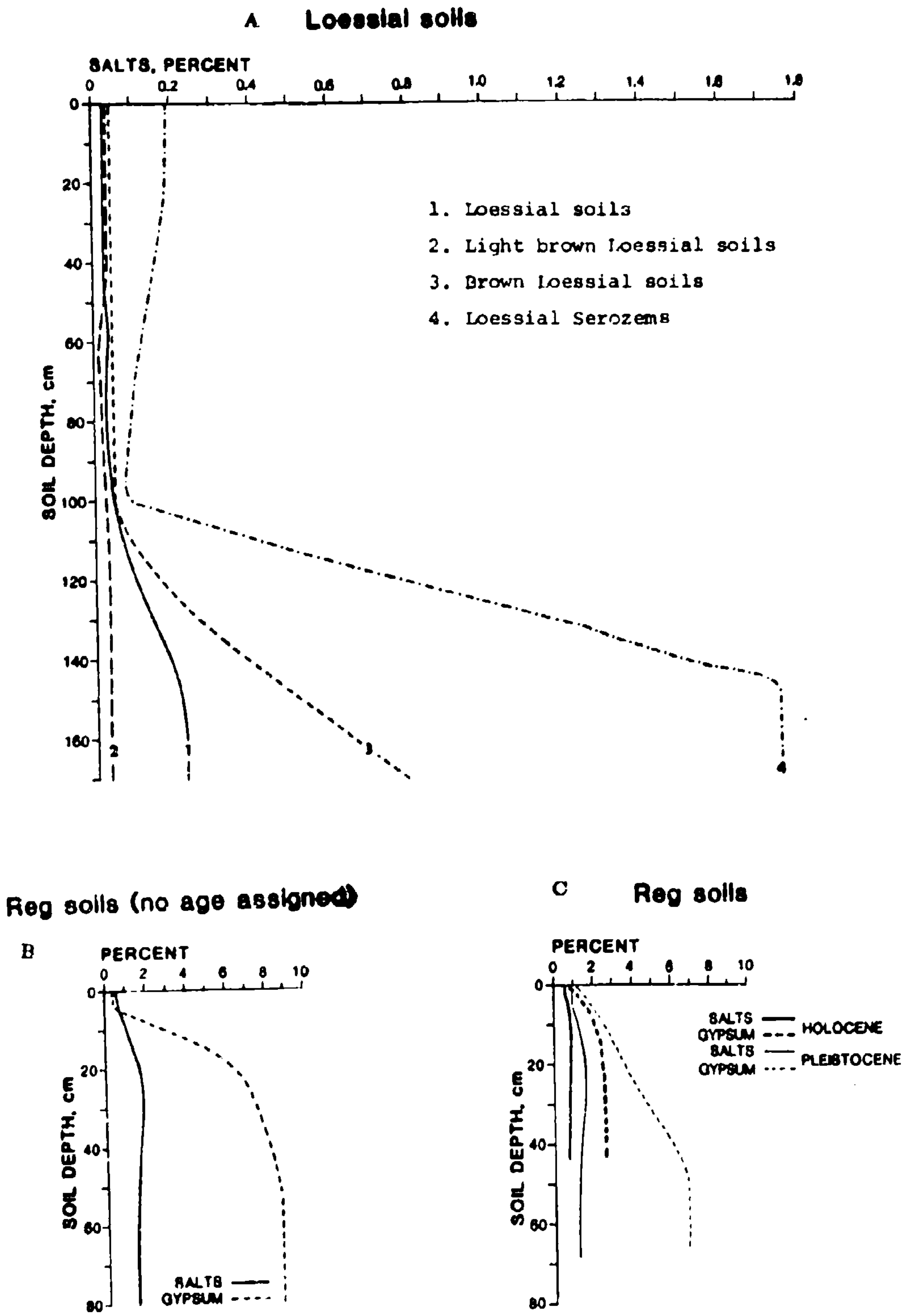


Figure C.3.22 The average content of salts and gypsum in various aridisols.

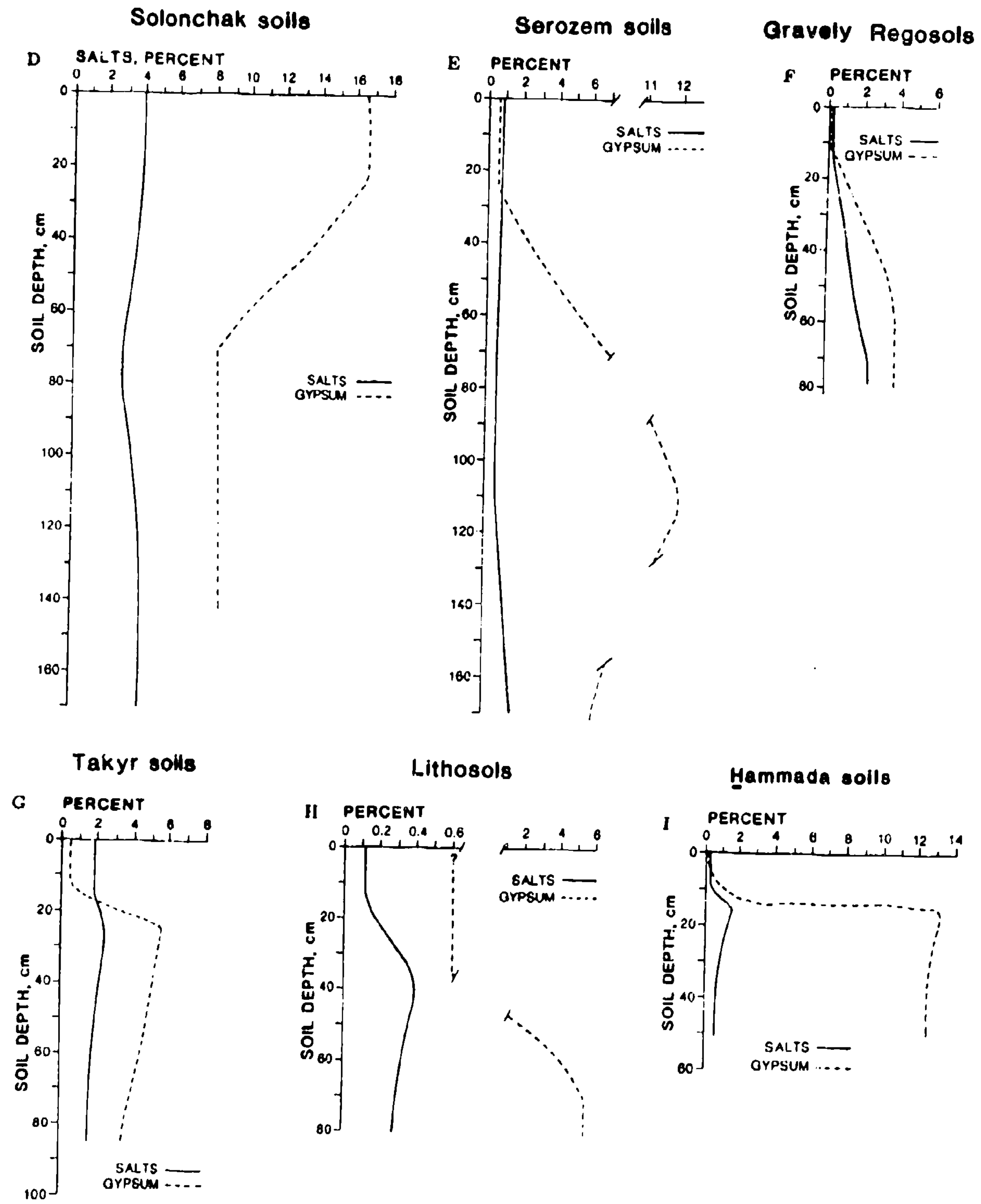


Figure C.3.22, Continued

C.4 GROUND COVER — TYPES AND OCCURRENCE

Soils and surficical deposits in deserts are often mantled by some crust — a well defined surficial horizon, different in its texture and structure from the underlying material. In many cases, the surficial horizon is more cohesive, durable and erosion-resistant than the underlying horizon. This is more often the case in soils than in other surficial deposites. In other instances, some indurated horizon was brought to the surface by the erosion of an overlying softer layer. The surficial crusts vary in their composition, structure, thickness and degree of induration. Several major types should be presented:

1. Loess Crusts

Loess crusts are thin crusts (2–3mm), usually of loam-silt-loam texture (plate 15C). They are widely spread on loessial deposits and between surface rocks in Reg soils on alluvial and talus surfaces. Loess crusts are composed mostly of silt and clay, densly packed and unaggregated (Chen et al., 1980). They are formed by two groups of processes: (a) Mechanical dispersion and deposition by raindrop impact and surficial runoff (Morin et al.,1981; Tarchitsky et al., 1984). (b) Chemical dispersion, washing-in and accumulation of clays (Agassi et al ., 1981).

2. Biogenic Crusts

Lichen, algae and mosses often form a surficial layer over fine grained soils and debris. The resulting crusts protect the underlying profile from the impact of raindrops and erosion by runoff and winds. Dust is usually trapped by lichen colonies and mosses and between them (Danin and Yaalon, 1981). The resulting crusts, composed of dust, plants and precipitated salts are of variable thickness: In the vicinity of Jericho (-100 mm/year of mean precipitation) a ≤ 20 cm thick crust has developed during a period of several thousand years over chalks and marls of the late Pleistocene Lisan Formation. Near Massada, some 50km to the south (-60 mm/year of mean precipitation) the crust is only a few mm thick (Danin, 1984; personal information).

3. Crusts on Playa/Sabkha Surfaces

Surficial layers of playa surfaces are diversified. Three main types are apparent:

(a) **Clayey crust.** These crust, composed of 40-75% clay appear in playa centers which are covered occasionally by flood water. The coarser fractions are left behind, in the playa margins (see Part D). Fine airborne dust is added to the surface while it is wet. In these playas there is no permanent shallow water table and the surface is dry for long periods of time. Salts in large amounts are not added and in fact they are leached by percolating floodwater. The crusts are hard, smooth and devoid of vegetation, overlying Takyr soils.

(b) **Salt Crusts** are typical to playas and sabkhas where high groundwater level is discharging water to the surface, repeatedly or continuously. The salts precipitated upon evaporation are mostly chlorides, sulphates and some carbonates. Crusts of variable thickness are formed. The surface is usually rough, composed of small crests and troughs, polygons of various sizes and small solution pits (Krinsley, 1970; Cooke and Warren, 1973). During long periods of time the soil (Solonchak) is wet and soft at the surface.

(c) **Soft puffy surfaces** are frequently encountered in playas where rapid capillary rise of water is derived from a very shallow water table. The micro-topography of such surfaces may attain 15 cm. High salt content and rather large particls sizes — sand and silt (very little clay) are typical. The surfaces is periodically wet. Shallow water inun-

dation occasionally occurs; dissolution of salts and smoothing of the surface takes place, only to become rougher again upon drying.

4. Surficial Gravel

Gravel (pebbles, cobbles, stones, grit) appears on many landforms developed or derived from hard brittle bedrock: stream channels, alluvial fans, alluvial flood plains, rocky plateaus, hillslopes. Rock blocks of various sizes are exposed by erosion of hillslopes and are carried downstream. The size of the gravel is governed by several factors: joint spacing, breakdown and attrition during periods of movement, sorting during periods of transportation and weathering during periods of rest. The general trends are described in Part D and figures D.1, D.2. It is during the period of long rest that dust is added to the gravel, through weathering and introduction of airborne materials: Reg soils, Hammada soils and Lithosols are common results of the movment of water, and the deposition of dust and salts whitin the gravelly debris mantle.

5. Desert Pavement

Desert pavement is a gravelly surficial cover of $\geq 40\%$, overlying a fine soil horizon. It is usually composed of coarse fluviatile gravel, partly or completely shattered by mechanical weathering. The resulting gravel is often 1–7 cm in median diameter; it is stable in place, lying flat, short axis vertical (plate 11A). Desert pavement is characteristic to gently sloping coarse-alluvial plains that are not fluvially active, Hammadas on rocky flats and talus slopes of medium and gentle gradients. The stones may be varnished or pitted on the upper side.

Several processes are involved in desert pavement evolution: (a) Mechanical weathering of original gravel; (b) Winnowing and washing away of fine particles (< 2mm) by wind, runoff and percolation; (c) Migration of gravel towards the surface; (d) Downward movement of dust introduced by wind and rain — fine sand, silt, clay. With time, a thin (0.5–7.0 cm) loamy vesicular horizon develops underneath the gravel and between the discrete rocks. In the latter cases it is covered by a thin loess crust. During several tens of thousands of years a gravel-free B horizon may develop under the vasicular layer.

The course of evolution of desert pavement on alluvial surfaces is as follows: (a) At an early stage there is usually an almost complete cover (75–95%) of the surface by fluviatile gravel and some fines. At this stage there is a gravel bar and swale topography at the surface. (b) During a later stage there is a slow obliteration of the gravel bars by the mechanical weathering of the surficial gravel, trapping of airborne dust underneath and between the surficial gravel and evolution of Reg soils (Hammada soils may develop in a similar manner). Figure C.1.9 illustrates the change of pavement cover with time on a Holocene sequence of alluvial surfaces. (c) Several 10^4 years elapse until the surface is composed mostly (>85%) of secondary (mechanically weathered) angular gravel and the differences in elevation between bars and swales (being originally 20–60 cm) are completely eliminated. The conditions that determine the rate of this process are the size of the original gravel and the surficial features, the ability of the water to penetrate the individual rocks and the amounts and composition of the salts available for the mechanical weathering process. A smooth surface of desert pavement on alluvial surfaces composed originally of small cobbles and pebbles, indicates an age of more than 13,000 years (Bull, 1974; Bull, in preperation; Ku et al., 1979) and in most cases more than 30,000 years. (d) After several 10^5 years, when the soil profile is highly plugged with fine silt, clay and salts, there usually occur a stripping and erosion of the Reg soil and some indurated crust, composed of gypsum, salts or calcium carbonate may be exposed at the surface.

PART D: GRAVEL IN DESERT SOILS AND DEPOSITS – SOME COMMENTS ON POSSIBLE RELATIONSHIPS TO DUST

The present report deals with the fine fractions; however, it is still necessary to have an overview on the accompanying material — gravel. The following treatment is rather general, but it certainly complements the broader picture.

Gravel in desert terrains is readily available due to the significantly high rate of mechanical breakdown of the bedrock. Salt weathering is predominant on the widespread rocky outcrops as well as at the bottom of the shallow Regosol, Hammada soil, and Lithosol profiles. The debris produced by mechanical shattering is readily transported by the high rates of runoff from rock exposures caused by intensive rainfall. Sorting in the size of gravel takes place as the debris is transported down the fluvial system: the finer fractions are carried farther downstream into the depositional basins.

Wind erosion and transport are significant processes in winnowing sand and dust from eroding terrains as well as from depositional landforms; the finer fractions accumulate in downwind areas, such as sand fields and loess plains. Gravel is left behind as a lag deposit with very little fine matrix. Figure D.1 broadly summarises the general subject of the origin, transport and deposition of gravel in fluvial and interfacing systems in deserts.

The size of the gravel is dependent on several factors:

1. Joint spacing, determining the size of potential rock debris.
2. The available power to detach and transport gravel downslope and downstream.
3. Weathering and abrasion of rocks during periods of repose and transport, respectively.

The following are the types of agents that may carry very coarse gravel (large cobbles and boulders) downslope and downstream into the depositional basins:

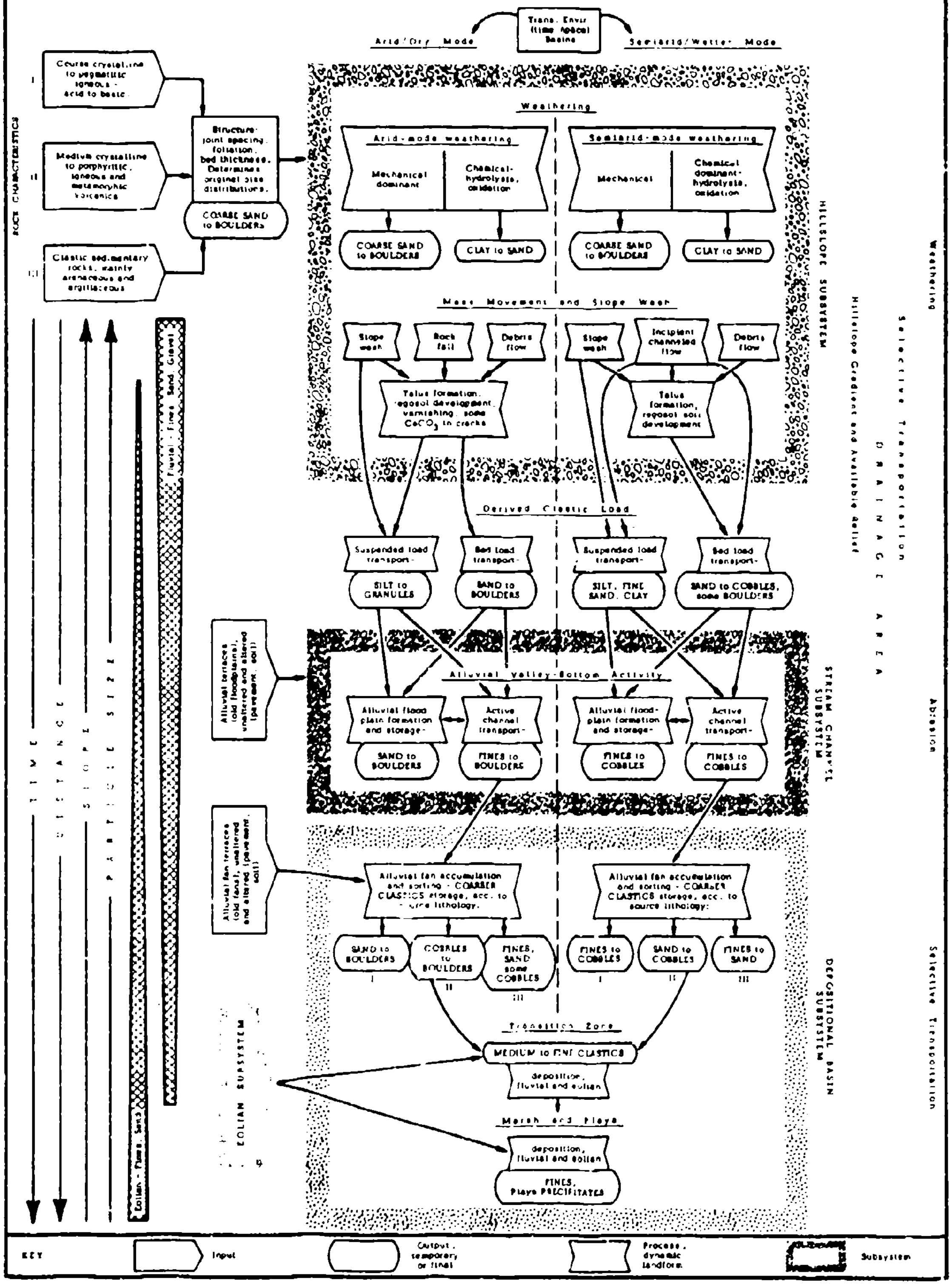
1. Debris flows, carrying large unsorted gravel in a matrix of fine earth materials (Plate 6).

2. Flashy floods, typical to terrains of large rocky outcrops under intensive rainfall. Debris flows are characteristic of steep hillslopes under long term moderately arid – semi-arid climatic regimes while flashy floods are more typical of desert terrains under arid through extremely arid climates (Gerson, 1982).

The effects of climate are clearly demonstrated by analysing sedimentary units in deserts. For example, high Pleistocene alluvial terraces and fans at the foot of escarpments include in their sections a high proportion of debris flow deposits representing climatic regimes wetter than at present. The lower group of alluvial terraces exhibit stratified and lenticular coarse and fine fluvial sediments, typical of the more arid regime of the Holocene (Gerson and Grossman, 1985).

Many watersheds in the southern Mojave and Sonoran Deserts show three types of gravel, either in a single terrace or in separate terraces (fig. D.2). These include fine, well sorted gravel often in a fine earth matrix (red in color), overlain by coarse unsorted gravel mixed with sand, and sand with some gravel as in many present-day channels. These represent three types of environments, respectively: 1. Moderately arid to semi-arid or a transition from such a climate to a distinctly more arid one; 2. An extremely arid to arid climate with coarse gravel available for transport and deposition by flash floods; 3. Stream channels in watersheds under extremely arid climates of long duration, where hillslope colluvia and regolith are depleted and

Figure D.1 ORIGIN and DISTRIBUTION of GRAVEL in STREAM SYSTEMS of ARID REGIONS



In many soil types and other deposits, gravel is a major component and is often found interspersed with fine earth (sand, silt, clay). With time, these deposits develop a loamy gravel-free A_v and B horizons overlain by a fine to medium sized gravelly desert pavement. Such are generally old Reg soils and sometimes old Hammada soils (plates 11, 13). The gravel-free horizons are formed by the penetration of settling atmospheric dust with percolating rain and runoff water. The spaces between the original coarse particles are gradually filled with dust. Accretion of additional dust forms the gravel-free horizons. It takes several 10^3 years for a 0.5 - 1.0 cm thick A_v horizon to develop, some 5 - 15·10^3 years for a 3-5 cm thick AB-B gravel-free horizons to form, and 5-10·10^4 years for a thick (several decimeters) gravel-free horizon to be established. Dust accretion in the C horizon is rather slow, and it therefore remains highly gravelly. Concomitant with the accretion of dust there is a gradual salinisation process. The B and C horizons become gypsic and salic (or calcic) with time (see Chapter C.3). Precipitated salts eventually constitute tens of percents, by volume and weight, of the non-gravelly fraction. A well developed gravel-free horizon in Holocene Reg soils is rather rare. A clear bar and swale topography on gravelly alluvium (Plate 5B) may be associated with a <10 cm thick gravel-free or a gravel-poor horizon. Well developed late Pleistocene Reg soils may usually have a ≤25 cm thick gravel-free layer. More frequent are soils with such horizons 5 - 15 cm thick. A similar range of thickness is typical of gravelly soils on talus slopes. The mature gravelly soils are always associated with a smooth desert pavement, (Plates 11, 14). The upper part of gravelly sieve deposits stay highly porous for very long periods of time. Only very old surfaces composed of such deposits may have gravel-free horizons, but this situation is rather rare. Most Hammada soils are very irregular with respect to gravel content and in-situ rock blocks. Usually one observes a lateral transition from exposed bedrock into mechanically shattered rocks with some dust concentrated in pockets. Sometimes well developed desert pavement overlies patches of a gravel-free B horizon (Plates 11A, 14D).

Summary

1. The ratio of fine earth to gravel increases with time in most gravelly soils on stable surfaces (Reg soils, Hammada soils)

2. A gravel-free layer tends to develop in-situ with time under a desert pavement on stable surfaces composed of coarse alluvial gravel and mechanically weathered hard rocks. A continuous, smooth desert pavement usually denotes a gravel-free, loamy-silty horizon underneath, generally thicker than 10 cm.

3. A well developed desert pavement is usually composed of well sorted gravel, 1.5 - 7.0 cm in diameter. This hinders size estimations for the gravel layers/horizons underlying the gravel-free horizons. However, there is a general decrease of gravel size and better sorting downstream in a channel or alluvial fan. This principle may serve as a guideline for size estimation if the gravel underlying the surface is of interest.

4. Soil profiles and deposits in downstream reaches usually include more fine earth sized materials than upstream.

5. Very coarse and unsorted gravel is expected in debris flows and along stream channels and alluvial terraces of water courses draining steep mountaineous watersheds wher hard rocks are exposed.

6. Hammada soils and Lithosols are most variable in their general content, size and distribution. It is extremely difficult to generalise or predict their gravel composition.

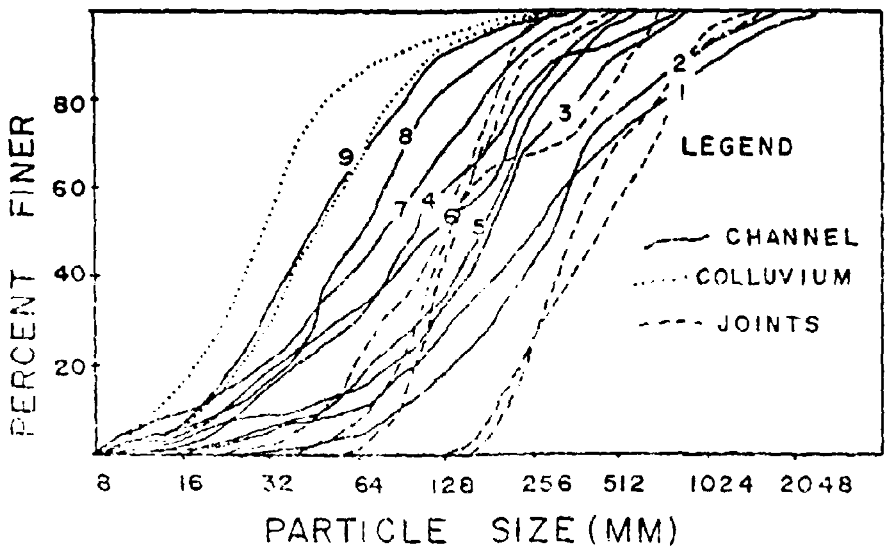


Figure D.2a Cumulative frequency distribution of particale sizes of gravel sampled on modern channel, colluvium and joint blocks (Mohawk Mts., southwestern Arizona).

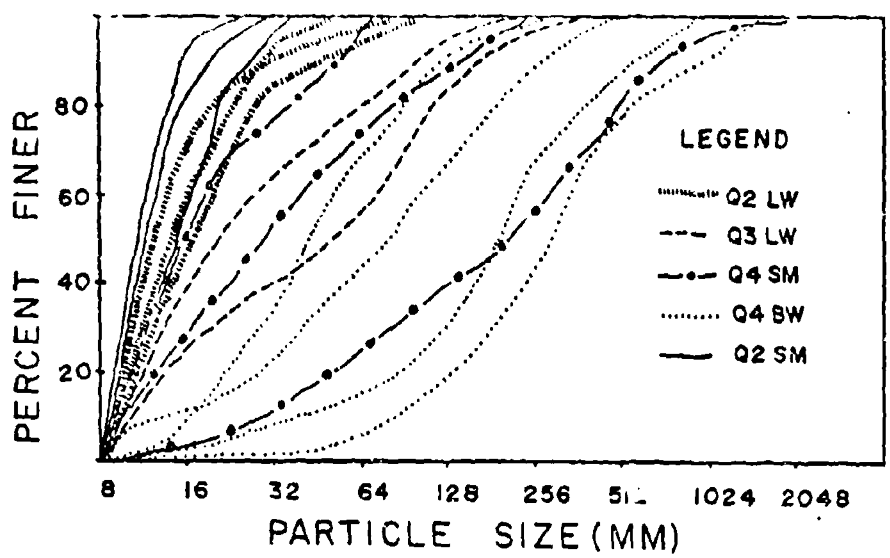


Figure D.2b Cumulative frequency distribution of particale sizes of gravel from different aged deposits. Q_2 — late Pleistocene. Q_3 — Holocene. Q_4 modern channel.

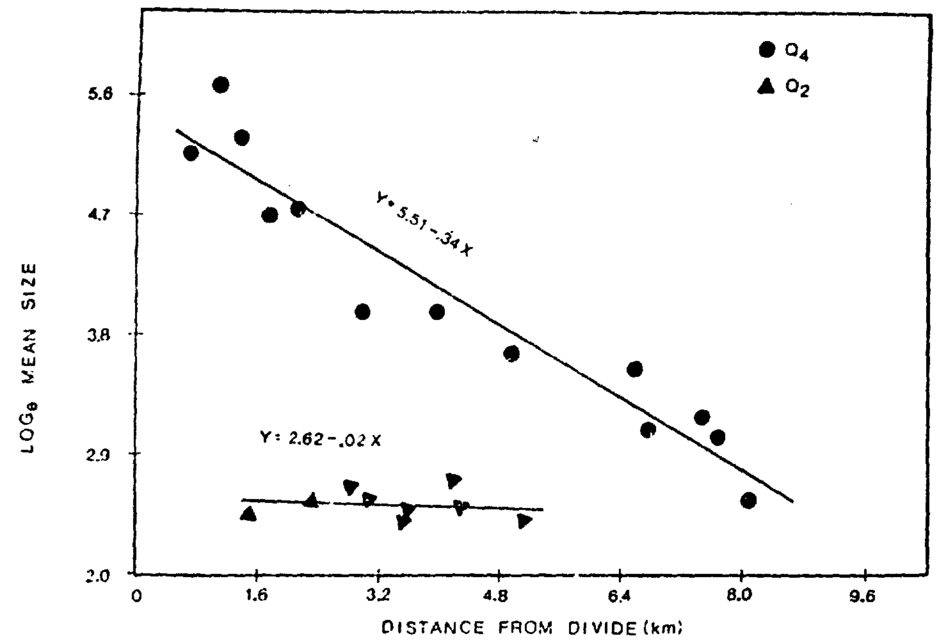


Figure D.2c Regression lines for Stoval-Mohawk (southwestern Arizona) particle size data. Q_4 — modern channel. Q_2 late — Pleistocene terrace fill.

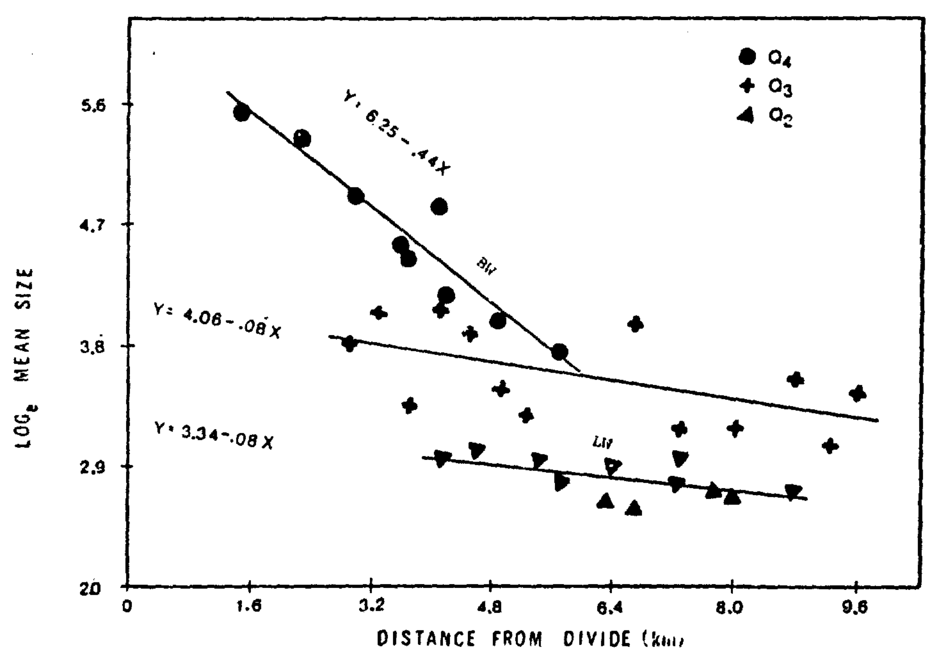


Figure D.2d **Regression lines for Boulder Wash-Lizard Wash area (Gila Mts., southwestern Arizona). Upper curve is for Boulder Wash. Lower two lines describe the desert pavement relationships for Lizard Wash.**

PART E. SUMMARY AND DISCUSSION

E.1 SOME ENVIRONMENTAL EFFECTS ON DESERT SOILS AND DEPOSITS.

On The Effect Of Climate On Desert Soils

The climatic regime is reflected mainly through the availability of water -- the amounts, duration and intensity of the precipitatition; the frequency of rainfall events, the duration of dry periods; the rate of evaporation. Wind and temperature should be taken into consideration while evaluating water availability.

The availability of water effects the following processes and their products:

1. **Mode and rate of weathering.** Generally, the more arid the climate, the more significant is the process of mechanical weathering, compared with chemical decomposition. In extremely arid environments one should expect predominance of gravel, grit and sand. Under semi-arid climates grit, sand and fines may be produces in appreciable amounts or even predominate.

2. **Water infiltration.** The depth of water infiltration depends mainly on the amounts, duration and intensity of rainfall, antecedent moisture, porosity and permeability of the soil. **The thickness of the soil profile** and the soil horizons, the penetration and distribution of airborne dust and salts and the modes and zones of weathering — all are dependent on the infiltration of available water. The thickness of the soil profile is a readily observable property; in most soils it is directly effected by the degree of aridity. Soils of a particular type in the extremely arid southern Negev are shallower than the soils of the same type in the less arid northern Negev. The shallowness of the Reg soils of Holocene age reflect the aridity of the latest Quaternary, compared with the thicker soils of late Pleistocene or earlier periods (see chapter E.2). Similar trends apply to the thickness of discrete soil horizons.

3. The composition, distribution and content of salts in the soil are controlled mainly by water availability, depth of water penetration, and evaporation. These factors determine the degree of leaching and differential precipitation of salts of different solubility — carbonates, sulfates and chlorides. The "gradient" of salinity, the types of salts and the depth of salt precipitation with climate is generally accepted and is summarized by Dan & Yaalon (1982) and Birkeland (1984). Calcic soils are characteristic of semi-arid to arid terrains, whereas gypsic-salic soils are typical of the extremely arid environments. However, the distribution of rainfall through the year and the resulting vegetation may change this pattern through the change of the effectiveness of precipitation. In desert areas of two-season rainfall regimes or where snow is a substantial component, there are instances in which extremely arid environments receiving 60–80 mm of precipitation, lead to development of calcic soils. Such is the case of the southern Mojave and northern Sonoran Deserts.

For further discussion on the effect of climate and significance of local environmental factors, such as topograhy and aspect, see the following section.

Local Environmental Effects

The amount, composition and distribution of dust and salts in desert soils and deposits are greatly influenced by three basic elements: 1. Topography; 2. Aspect; 3. Location — relative to adjacent landforms. These elements may exert their influence in different degrees and combinations.

1. **The effect of topography.** The development of a catena — a sequence of soils along a hillslope, changing in properties due to the distance from the crest, gradient, drainage and history of the soil — is relatively rapid. A clear catenary development in young gravelly soils was found on risers of Holocene alluvial terraces across the Negev . Thick (15-30 cm) gravel-free B horizons have developed at the foot of these risers and thin AC type profiles are characteristic on the backslopes which have reached gradients of 18°-20°. The general catena is: a. Reg soils of the ABC type on the tread of the terrace; b. Truncated ABC profiles, into AC profiles, on the crest of the slope; c. AC or C profile on the backslope part of the risers; d. Well developed ABC profiles at the footslopes.

On risers of gravelly alluvial terraces of Pleistocene age there are typical ABC soil profiles along most of the slope. The catena expresses stability, with gradients $< 18°$. Leaching is pronounced, especially on the downslope segments, since these portions receive runoff water from the upslope areas. Concentrations of gypsum and salts are found at deep horizons in these soil profiles — 35-60 cm below the surface.

On many hillsopes carved in limestone and dolomite (plate 1A) there is a characteristic toposequence: a. Lithosols on the crest and backslope; b. Stony serozems on the lower backslope and upper footslope; c. Loessial serozems on the footslope and toeslope (Dan,1966; Dan et al., 1982). On the lower, colluvial segments there is usually a calcic horizon at shallow depth and concentration of gypsum at deeper horizons (Arsi,1981; Wieder et al., 1985). On the lower toeslopes, farther from runoff contributing backslopes, there is often a gypsic horizon above a calcic horizon — evidence of the very xeric regime in such sites (Arsi, 1981).

Different trends were found on gravelly talus slopes at the base of escarpments (plate 7A): The lower portions of the slope carry Reg soils which are less saline and more dust-rich than the soils on upper segments, due to the activity of runoff and wash contributed from the latter.

In loessial soils in the semi-arid northwestern Negev there is a trend of formation of a clay-loam B_2 horizons on the footslopes — segments that receive both water and clays from the backslope parts (Dan,1966). The soils on the footslope segments are definitely thicker than on the backslopes and often — on the toeslopes

Within a given hillslope there is often a pronounced difference between the soils of adjacent sites. Such a variability is observed in the transition from bare rocks or shallow Lithosols to loessial Lithosols or Serozems in patches downslope (Danin, 1970; Arsi, 1981); the latter have in many cases a clay on clay-loam texture and low salt content. Reg soils on Holocene alluvial surfaces show high variability in texture and salinity (Amit & Gerson, 1985): the soils on gravel bars tend to be coarser-grained and more saline in their fine earth fraction than the soils on the swales — abandoned channels — due to wash from the former into the latter.

2. **The influence of aspect** — direction of the hillslope. It is a well established conclusion that hillslopes facing the sun are usually drier than those directed away from the sun. In the Negev, this was well documented for both soils (Dan,1966; Arsi,1981) and vegetation (Da-

nin,1970). Several factors that determine the properties of the soil are related to aspect: a. Water availability and effectiveness. The direction and inclination of falling rain are controlled by wind direction and velocity, respectively. Thus, more rainfall reaches west and northwest facing hillslopes than east and southeast facing hillslopes in the Negev (Sharon,1983). Hillslopes facing northwest and west may receive 30-70% more annual rainfall than those having the opposite direction. The difference during discrete rainstorms may reach 50-100% (Sharon, 1980). Desiccation of sun-facing hillslopes render them more arid than those facing away from the sun. In the case of the Negev both rainfall direction and sun direction combine to accentuate the differential moisture between north and west facing hillslopes versus south and east facing ones. b. Vegetation manifests the difference in aridity very clearly: in the arid hilly northern Negev one usually finds the sygophyllum dumosum (sage brush) plant association on south facing hillslopes, whereas the Antemisia herba-albae (burley bean caper) plant association predominates the north facing ones (Danin 1970).

Dust accretion, being dependent on wind direction and velocity, surficial moisture and vegetation, illustrates the effects of aspect. For instance, there is a thicker loess mantle on north facing hillslopes than on south facing ones in the northern Negev (plate 2D). The same trend is apparent in the depth of salt precipitation — it is shallower in soils on south facing hillslopes.

3. **Location relative to adjacent landforms.** Dust and salts, as allochtonous materials in most desert soils, are sometimes derived from landforms and physiographic regions adjacent to the site in question. Soil at sites located downwind of source areas of dust or salts will show larger amounts of these materials and a rather high degree of development. For example, in the southern Arava Valley — a region located downwind of vast source areas for dust and salts; northern winds blow over this area most of the time. The soils and deposits in the southern Arava are richer in fine sand, dust and salts than soils and deposits of comparable origin and age further north along the Dead Sea Rift. Another example is the lava flows of latest Pleistocene age in the Cima Volcanic Field in the southern Mojave Desert (Wells et al., 1984): large amounts of dust have been trapped in the Hammada soils on this flows, located downwind of the source areas of Soda Lake and Silver Lake playas (see chapter E.2: Rates of Dust Accretion in Deserts).

On The Impact Of Climatic Fluctuations On Aridic Soils.

Climatic regimes, if in effect for a sufficient length of time, may produce long-standing prints in some types of aridic soils. Pedologic activity during periods of several 10^3 to several 10^4 years is necessary to reflect a particular climatic regime. The effect of such a regime may be overshadowed by certain local effects as describes in the previos section.

The properties, or qualities, which depend on climate in aridic soils are:

1. The thickness of the soil profile and the soil horizons.
2. The texture of the allochtonous dust-sized fraction.
3. The composition and the distribution of the secondary, pedogenic salts in the various soil horisons.
4. The altered mineral species, the quality of the iron oxyhydroxides and the clay minerals in the soil.

5. Certain micromorphological features such as clay films.

All these characteristics are largely dependent on the hydrologic regime at the surface and within the soil profile. The hydrologic regime is controled by both the climatic elements — precipitation, temperature and wind, and by the hydraulic properties of the parent material or the soil profile. The latter changes significanly with time (see chapter C.1)

There is no sufficient data about some of these factors; especially there is no quantitative analysis or sound guidelines for their combination to be applied to a paleoclimatic interpretation. However, several trends should be emphasised here.

1. **The composition and distribution of the pedogenic salts** are indicative of the effective moisture. The differentiation between $CaCO_3$-rich soils and gypsum-salt-rich soils may serve as a sound basis for separating moderately arid to semi-arid environments from arid to extremly arid ones (Dan & Yaalon,1982). For example, while calcic soils are predominant in the semi-arid to moderately arid northern Negev, the soils in the extremely arid southern Negev are gypsic-salic. Wherever we do find calcic soils in the southern Negev, they are pre-late Pleistocene paleosols or have developed under special environmental conditions. In some areas, such as the Grofit Plateau, we find thick (2–15m) calcic loessial paleosols similar to those formed during the middle to late Pleistocene in the northern Negev.

2. **The thickness of the soil profile** serves as an indicator of the depth of penetration of meteoric water. This property, if compared in soils formed on similar parent materials, may be used for assessing the relative availability of moisture, reflecting effective precipitation. A case in point is Reg soils on Holocene versus Pleistocene alluvial surfaces: the soils on the Holocene surfaces are shallow — less than 50 cm in depth — whereas many late Pleistocene Reg soils are thick — more than 1.0m in depth. The latter have developed under climatic regimes that must have been effectively wetter than the former. It is not the time factor that has led, indirectly, to the development of the thicker, older soils; available moisture had to be effectively larger (for elaboration on late Pleistocene climates, the reader is referred to Horowitz, 1979; Goldberg, 1981; Gerson & Grossman, 1985).

3. **The mineralogical composition of some soil components** may bare evidence to past climatic regimes. However, most of these mineralogical components should be taken only as indicators to climatic regimes and climatic changes and in most cases not as a conclusive evidence. In section 1 above we have described the existence of calcic paleosols in areas where gypsic-salic soils are the rule at present. Clay composition of aridic soils is often mentioned as a possible indicator of different past climates. The composition of the dust fraction in aridic soils should be treated cautiously since most of it is derived from airborne sources. The composition of this recycled dust is determined by the weathering processes in the original sites of production, by the alteration in former sites of deposition and by the mixing of dust from differnt sources. However, few components may still serve as climatic indicators. One example is kaolinite in soils located in sites where kaolinite is not preferably abundant. In some soils, such as fossil Terra Rossa and calcic argillic paleosols, there is a predominance of kaolinite, much of which is well crystallized; this is so in terrains where montmorillomite is predominant in the younger soils which have developed under climatic regimes similar to the present. The former soils have developed under climates wetter than at present. Gleyed soils are not frequently found in deserts. However, we do observe traces of reduction and gleysation in old paleosols in sites where no such processes are active at present; stream valley bottoms are one case. Former flood plains were in some instances perennially inundated whereas the present-

day channels are ephemeral and dry most of the year.

4. The relative formation and accumulation of the various iron compounds — goethite, ferrihydrite and hematite — may point at the climatic regimes under which the soil has developed (McFadden & Hendriks,1985). Hoewer, the separation of the effects of the time factor from those of climate is still a major drawback in the interpretation.

5. Micromorphological features hold potential for a paleoclimatic interpretation. For example, clay films are abundant in gravelly soils that have developed under modetately arid to semi-arid climates whereas in such soils developed under extremly arid climates they are absent or only slightly apparent.

We may accept an interpretation of past climates which were different from the present in cases where several soil properties support such a case. Only in certain cases may we use a single property as a conclusive indicator of a different paleoclimate — calcic soils in sites where gypsic ones are presently characteristic and gleyed paleosols in sites where gleysation is not active at present. In the case of fossil Terra Rossa in desert terrains we belive there is no doubt about past climates very different from the present (the present is treated here as if it is a time for which the climate is fairly well known).

E.2. EVALUATION OF DUST IN DESERT TERRAINS — COMPOSITION AND AMOUNTS

Note: Chapter E.2 emphasises results and conclusions of Parts C and D. See the summaries of the chapters in the parts for additional conclusions.

The Composition of Dust

The composition of the dust fraction in desert soils and deposits is related to several sources, such as parent material, the composition of allochtonous — mostly airborne — dust and the nature of the precipitated salts. The composition of the airborne dust is largely reflected in the dust fraction of most desert soils and deposits. Generally, it is composed of ~50% of medium to coarse silt. Minor amounts of clay and fine sand are always present. However, addition of various size-fractions or differentiation by pedogenic processes may significantly change the original size distribution according to location, topography, climate and age (see chapter E.1). Especially important is the contribution of sand from eolian and fluvial sources. Soils in areas close to actively contributing sandy terrains are usually sandy to sandy-loam in texture, whereas the texture of soils several tens of km or more from such areas are generally silty-loam to silty-clay (see chapter C.1). The soils and deposits which are largely derived from distant eolian sources are usually of finer texture.

Table E.2.1 summarises the general properties of the soils and the deposits analysed in the present study. There is no single principle which can guide an objective grading of desert soils according to their dust content, composition and distribution. Hence, the types of soils in table E.2.1 are organised according to the following guidelines:

1. The abundance of dust in the soil profile — maximal in loessial and Takyr soils and minimal in active sand dunes and coarse gravelly alluvium.

2. The association of the soil (or deposit) with a particular type of landform (see chapter A.3).

3. The age of the soil, within a given soil type. In most soils there is an increase of the fine fractions (including precipitated salts) with time.

Figure C.1.16 expresses the dust content in the various desert soils and deposits in the Negev and the Sinai. A summary based on the data presented in chapter C.1, table E.2.1 and fig. C.1.16 emphasises the following points concerning dust in the different soils:

1. **Loessial soils.**

Young loessial soils are usually silt-loam in nature whereas well developed loessial soils have a texture of silty-clay and silty-clay-loam. These soils are usually devoid of gravel and coarse sand. Loessial Serozems are composed mostly of silt and clay but their particle size distribution varies greatly. The amount of fines (silt+clay) in loessial soils usually exceeds 50% and often reaches 90%. The ratio between clay and silt usually ranges between 0.4 and 0.8. Generally, these soils are similar in texture to settling atmospheric dust.

2. **Takyr soils**

Young Takyr soils are silt-loam in texture, whereas well developed Takyr soils are usually silty-clay and silty-clay-loam. The soil is composed of 60–100% dust, including 40–60% clay. The clay/silt ratio is usually 0.6–2. As with loessial soils, they are similar in texture to settling atmospheric dust.

TABLE E.2.1 SOIL TYPES AND SURFICIAL DEPOSITS IN DESERTS: GROUND COVER, PROFILE CHARACTERISTICS, DUST AND SALTS

Soil Type;Type of Surficial Deposit [1]	Ground Cover [2]		Thickness of Soil / Deposit [3]		Horizon [4]	Thickness of Horizon		Silt + Clay, % of the < 2mm Fraction(average) [5]			Average Estimated < 2mm, % [6]	Soil (averag Clay %
	Type of Cover	Average Cover,%	range cm	average cm		range cm	average cm	min	max	ave		
Loess	loess crust	100	43-200	131	A	5-35	20	16	19	51	100	37.2
					B	98-132	114	36	92	55	100	44.1
					C	98-120	108	17	79	52	100	-
Brown Loessial Soil	sandy loam	100			A	7-41	24	54	70	64	100	-
					B	73-104	88	61	72	68	100	-
					C	103-135	119	59	64	61	100	-
Light Brown Loessial Soil	silty clay loam crust	100	165-210	157	A	0-26	14	30	60	46	100	-
					B	54-80	67	20	87	51	100	-
					C	115-157	136	4	92	58	100	-
Loessial Serozems	loess with some rock fragments		82-191	87	A	1-17	9	59	81	66	-	-
					B	61-87	74	50	91	76	-	-
					C	92-116	104	74	81	77	-	-
					Bb	121-168	143	71	78	76	-	-
Takyr Soil	loess crust	100	40-180	89	A	1-14	7	66	100	82	95-100	41.2
					B	13-22	18	64	100	79	95-100	58.2
					C	35-65	50	64	100	84	95-100	33.5
Solonchack Soil	salt crust or saline loessial /sandy crust	100	30-140	102	A	3-12	8	21	89	61	90-100	3.6
					B	60-102	86	89	91	90	50-100	-
					C	15-45	30	15	36	28	50-100	3.4

y. %[5] mm verage) ave	Average Estimated < 2mm. %[6]	Soil Binding Components[7] (average in the < 2mm fraction) Clay %	Salts Electrical conductivity mmho/cm	Salts Approximate %	Gypsum %	Comments
51	100	37.2	0.5	0.03	-	Parent material - loess.
55	100	44.1	1.4	0.09	-	Land is usually cultivated.
52	100	-	4.2	0.28	-	Variable friability of surficial crust.
64	100	-	0.9	0.06	-	The natural vegetation is of grass steppe type.
68	100	-	0.7	0.04	-	
61	100	-	0.2	0.01	-	The soil contains pedogenetic $CaCO_3$
46	100	-	0.6	0.04	-	
51	100	-	0.6	0.03	-	
38	100	-	0.8	0.05	-	
66	-	-	2.6	0.16	0.6	
76	-	-	16.6	0.98	2.9	
77	-	-	28.0	1.76	6.8	
76	-	-	21.6	1.36	6.2	
82	95-100	41.2	9.6	0.6	0.5	High soil moisture during at least part of the year.
79	95-100	58.2	34.4	2.15	3.2	Note zonation according to particle size, salinity and vegetation.
84	95-100	33.5	31.7	1.98	4.0	
61	90-100	3.6	24.8	1.56	4.5	A relatively high sand contents in coastal belts and in terrains adjacent to sandstone exposures
9?	50-100	-	4.1	0.26	-	
28	50-100	3.4	60.4	3.78	8.0	

2

TABLE E.2.1, Continued

Soil Type;Type of Surficial Deposit	Ground Cover		Thickness of Soil / Deposit		Horizon	Thickness of Horizon		Silt + Clay, % of the < 2mm Fraction(average)			Average Estimated < 2mm, %	Soil (average	
	Type of Cover	Average Cover,%	range cm	average cm		range cm	average cm	min	max	ave		Clay %	El co it
Surficial Sediment													
Coarse Alluvium	Coarse gravel	100	10-100	57	A	-	-	-	-	12	-	tr.	
					C	-	-	4	9	6	-	tr.	
Reg Soil,Holocene	desert pavement	48	35-50 (130*)	40	A	2-5	3.5	15	88	60	20	11.2	
	fluvial gravel	42			B	3-9	5.5	14	88	60	25	14.2	
	loess crust	10			C	14-40	27.1	1	75	33	20	4.8	
Reg Soil, Pleistocene	desert pavement	84	60-135	63	A	1-6	4	14	84	49	40	9.8	
	loess crust	16			B	10-22	16	12	86	48	40	12.7	
					C	30-53	42	3	84	33	40	10.4	
					Bb	20-34	27	18	86	55	-	15.6	
Reg Soil, Tertiary	desert pavement	97	150	150									
	loess crust	3			B**	9-12	10	58	88	78	60	22.9	
					Bb	100	100						
Gravely Regosol	loose gravel	93	30-150	58	A	8-15	8	3	99	47	30	11.1	
	sand and loess	7			B	2-9	8	5	62	20	40	3.5	
					C	33-38	35	7	75	39	10	5.4	

Silt + Clay, % of the < 2mm Fraction(average) min	max	ave	Average Estimated < 2mm, %	Soil Binding Components (average in the < 2mm fraction) Clay %	Salts Electrical conductivity mmho/cm	Salts Approximate %	Gypsum %	Comments
-	-	12	-	tr.	10.9	0.68	0	Poor cohesion. Low clay content. Good water penetration.
4	9	6	-	tr.	21.6	1.36	0.1	Scattered bushes and trees.
15	88	60	20	11.2	8.0	0.5	0.6	Notes on Reg Soils: Highly gravelly soils.
14	88	60	25	14.2	14.2	0.89	2.6	Mostly devoid of vegetation.
[illegible]	75	33	20	4.8	12.0	0.75	2.1	
14	84	49	40	9.8	10.3	0.84	0.9	A horizon is here defined as the fine top soil under[illegible] and between surficial cover.
12	86	48	40	12.7	22.7	1.42	8.6	
3	84	33	40	10.4	20.7	1.29	6.8	The soil is moi[illegible] during and after infrequent rainfall events, usually to depth < 20 cm.
18	86	55	-	16.6	18.3	1.02	39.0	*Holocene Reg soils 50-130 cm thick are rather rare.
68	88	78	80	22.9	17.8	1.11	10.9	**A single profile; only B horizons were sampled.
3	99	47	30	11.1	30.7	1.92	5.8	The gravelly Regosols presented here are developed on sieve deposits, on talus slopes.
5	62	20	40	3.5	8.9	0.56	1.2	
7	75	39	10	5.4	10.2	0.64	3.5	

TABLE E.2.1, Continued

Soil Type;Type of Surficial Deposit	Ground Cover: Type of Cover	Ground Cover: Avarage Cover,%	Thickness of Soil / Deposit: range cm	Thickness of Soil / Deposit: average cm	Horizon	Thickness of Horizon: range cm	Thickness of Horizon: average cm	Silt + Clay, % of the < 2mm Fraction(average): min	max	ave	Average Estimated < 2mm, %	Soil (average Clay %	Ele[illegible] cond[illegible]ity
Hammada Soil	coarse angular gravel	86	30-100	60	A	1-6	4	61	92	70	36	12.7	[illegible]
	loess crust	14			B	8-2[illegible]	16	29	83	64	66	18.6	2[illegible]
					C	32-60	41	16	64	40	36	16.6	7
Lithosol Serozem	rock fragments	60	66-100	40	A	0-14	7	37	79	61	-	-	4
												-	6
	loess & fine sand	60			B	16-39	27	68	84	71	-		
												-	4
					C	24-40	32	60	82	.	-		
Stony Alluvial Serozem	rock fragments	60	40-240	142	A	2-18	10	39	86	64	-	-	16
	loess & fine sand	40			B	52-78	66	27	63	78	-	-	10
					C	116-142	129	51	96	70	-	-	26
					Bb	118-166	136	76	89	83	-	-	6
Alluvial Sand	fine sand	100	106-300	188	A	0-36	17	16	29	22	100	-	0
					B	44-90	67	8	29	18	100	-	0.
					C	142-188	166	2	11	6	100	-	0
Sandy Regosol	fine sand	100	40-260	198	A	0-49	20	-	-	12	100	-	0
					C	142-188	166	9	16	13	100	-	0
Brown Alluvial Soil	silty clay loam Crust	100	200-260	121	A	2-8	10	29	71	46	-	-	13
					B	86-120	102	66	82	74	-	-	28
					C	87-121	104	10	86	42	-	-	11
					Bb	113-160	131	-	-	-	-	-	

	Average Estimated (...e) < 2mm, %	Soil Clay %	Binding Components (average in the < 2mm fraction) Salts: Electrical conductivity mmbo/cm	Approximate %	Gypsum %	Comments
	35	12.7	4.1	0.26	0.1	Highly gravelly soils.
	55	15.5	22.2	1.39	13.1	Sparse vegetation, grass, bushes.
	35	16.5	7.0	0.44	4.8	frequently appear in patches, pockets.
	-	-	4.4	0.28	-	
		-	6.0	0.38	0.6	
	-		4.6	0.29	5.4	
	-					
	-	-	16.5	1.03	0.1	
	-	-	10.8	0.68	12.1	
	-	-	25.4	1.59	7.2	
3	-	-	6.9	0.37	-	
2	100	-	0.4	0.03	0	Poor cohesion of the soil and the soil crust.
8	100	-	0.3	0.02	0	Good water percolation.
5	100	-	0.3	0.02	0	
2	100	-	0.8	0.02	0	Higher content of fines and better cohesion where vegetated (bushes).
3	100	-	0.2	0.01	0	
6	-	-	13.9	0.87	0.2	The soil is highly variable in gravel content, salinity and vegetation (grass, bushes).
4	-	-	28.0	1.75	0.1	
2	-	-	11.2	0.70	-	The soil may contain pedogenetic $CaCO_3$
-	-	-	-	-	-	One case of Bb.

Notes on Table E.2.1 (note number is marked at the head of the appropriate column)

(1) There is no single principle which can guide an objective grading of desert soils according to their dust content, composition and distribution. Therefore, the types of soils and surficial deposits are organized according to the following guidelines:

(a) The abundance of dust in the soil profile, maximal in loessial and Takyr soils, and minimal in active sand dunes and coarse gravelly alluvium.

(b) The association of the soil (or deposit) with a particular type of landform.

(c) The age of the soil, within a given soil type. In most soils there is an increase of fine fractions (including precipitated salts) with time.

A detailed description of the main soil types is presented in chapter A.4.

(2) Most soils in deserts develop a surficial layer or crust rather rapidly. Such a cover is different in composition and structure from the underlying layers or horizons; often the surficial layer is more cohesive and may determine the degree of potential of dust emission. Different ground covers are presented in table E.2.1, according to their texture, composition and the percentage of areal coverage. The types of cover are (see details in chapter C.4):

(a) Loess crust (dense and thin – 1–3 mm thick) on loessial soils, Takyr soils and between large particles in gravelly soils.

(b) Salt and gypsum crusts on Solonchak soils in playas and sabkhas.

(c) Desert pavement, usually composed of flat lying gravel developed on old gravelly deposits, with >40% gravel cover and an interstitial loess crust.

(3) The thickness of the soil profiles and horizons is most variable for many soils. The range and average is not always based on a large number of observations or measurements. The data include soils of different ages, degrees of development, and aspects. Hence the range of data should be considered as well as the averages.

(4) The designation of soil horizons is generalized as A, B, and C without further subdivision. This is so for the comparison of the general characteristics of the horizons and incorporation of data from sources additional to those collected in the present study.

(5) The textural subdivision employed here is as follows: (a) Sand – 2.0–0.063 mm. (b) Silt – 0.063–0.002 mm. (c) Clay – <0.002mm. Dust is defined as silt and clay – <0.063 mm.

(6) The data represent es[illegible]tes in the field. <2 mm includes fine earth, i.e. sand, silt and clay. The remainder is [illegible]ndifferentiated gravel.

(7) Several soil components affect soil consistency. Clay and salts (chlorides, gypsum, carbonate) are prominent among these. Chlorides and gypsum are the characteristic precipitates in the soils here considered. In some other deserts, such as the Mojave, carbonate predominates. Electrical conductivity represents the content of soluble salts, mostly NaCl; 16 mmho/cm equals approximately 1% of soluble salts. The data presented here are in percents of the fine earth fractions of the soil or deposit. The quantitative effects of earth of the three components on their observed combinations are not yet established.

3. Solonchak soils

These soils — very poorly developed — reflect the parent material in which they are formed — fluvially derived playa and sabkha deposits. In the southern Arava Valley and along the Gulf of Elat coast they are composed of sand, loamy-sand and sandy-loam; 30-70% sand, 10-20% silt and 1-10% clay. The clay/silt ratio is usually 0.6-1. The amount of gravel is usually very low — <5%.

4. Reg soils

These are silt-loam to clay-loam gravelly soils. In young — Holocene — Reg soils the fine earth is composed mostly (75-90%) of fractions coarser than 0.016mm; The dust fractions is usually 15-40%. Older Reg soils, in areas where there is no appreciable contribution of eolian sand, are rather fine textured: silt — 30-60% and clay — 11-25%. 60-85% sand in the soil is frequently encountered in areas adjacent to sandy terrains. The ratio of clay/silt is usually 0-0.4.

5. Hammada soils

These are silt-loam to sandy-loam gravelly soils. The ratio between coarse silt and fine silt+clay decreases with depth. Dust content in the fine earth is 40-60% and the clay/silt ratio ranges between 0.1-0.6.

6. Lithosols and Serozem soils

Both soil types are very diversified in nature. Dust content in the fine earth is usually 60-80%; most of the remainder is fine sand.

No good correlation was found between the content of silt and clay (chapter C.1). The most variable clay/silt ratios in different dust storms and rainfall events, as well as the high variability in wetting events and the properties of the parent material are the main causes for such a situation.

The composition and content of salts varies in the different soils. They are calcic in the moderately arid and semi-arid environments and gypsic-salic in the desert terrains. Following is a brief summary of the composition and content of salts in the soils of the Negev and the Sinai (further details and analysis are presented in chapter C.3 and table E.2.1):

1. The least saline are the **loessial soils** — <0.1-0.7% gypsum. The salts are usually concentrated at depth <30 cm.

2. **Takyr soils** are saline — 0.3-2% salts and 6-10% gypsum. In basins which are not completely closed the soils are definitely less saline — 0.1-0.2% salts and gypsum.

3. **Solonchak soils** are highly saline, especially in the inner playa zones; 2-10% gypsum and 0.5-8% salts are frequently encountered, but higher degree of salinity values were observed in many instances.

4. **Reg soils** are also saline. In Holocene Reg soils there is ≤10% gypsum and ≤2% salts. The higher values are encountered in the C horizon. In older Reg soils there is a high concentration of gypsum —≤20%. Salt content is usually ≤2%, but often there is a petrosalic horizon at depth of 0.80-1.5 m below the surface. **Hammada soils** are similar in salinity to Reg soils.

5. Lithosols and Serosem soils are usually saline — 0.1–15% gypsum and 0.1–1% salts.

6. The gypsum:salts ratio is usually the highest in Reg soils — ≤10. In Takyr and Solonchack soils the ratio ranges between 1:1 and 4:1. There is some leaching and wash of salts in gravelly soils whereas most of the gypsum is precipitated and is not leached away.

There is no correlation between the amounts of gypsum and other salts or between salinity and dust content. The evolution of soils under extremely variable conditions is a major reason for this situation (see chapter C.3).

The mineralogical composition of the particulate non-saline components of the dust fraction is determined by the petrographic composition of the parent materials in the source areas. Much of the dust is of mixed sources and has undergone several or many cycles of weathering, mobilisation, transport and deposition. Hence, in many areas there is only a partial effect of the composition of the local bedrock on the composition of dust. Most of the silt in the Negev and the Sinai is composed of quarts, calcite, feldspar and dolomite. The clay fraction is dominated by montmorillonite, with secondary amounts of kaolinite, illite and quarts (see chapter C.2). Similar composition prevails over much of the Middle East — a region largely effected by Saharan dust (see part B).

The effect of the local regional lithology is demonstrated by an area on the southern Rio Grande Rift ("The Desert Project" area; Gile et al., 1981) in southern New Mexico. There, in a region of wide exposures of acidic igneous rocks, there is a predominance of quarts, feldspar and mica in the fine sand and silt fraction. Montmorillonite and kaolinite are abundant in the clay fraction.

Only limited exposures show a definite compositional evidence of past environments, different from the present; for example, fossil kaolinitic Terra Rossa is found in certain areas of the arid central Negev (see chapter E.1 for elaboration).

The Amounts Of Dust In Desert Soils And Deposits

The environmental factors that determine the amounts and nature of the dust in desert soils and deposits are described in detaile in chapter E.1. Generally they are: 1. The nature and proximity of the source areas; 2. Climate; 3. Location; 4. Topography; 5. Aspect; 6. Surface roughness; 7. Vegetation; 8. Hydraulic characteristics of the material near the surface. According to the amounts of dust imported into an area, the quantities of settling dust and surficial properties, one may grade the general terrain types and the soils with respect to their dust content, from the richest to the poorest:

1. Loessial terrains — composed mostly of eolian and reworked silt, clay and fine sand. Such terrains are rich in dust due to a combination of their location with respect to the sources of dust, the atmospheric circulation and the climate — moderately arid to semi-arid — that lead to a high rate of dust settlement and a most efficient dust-trapping vegetation. Thick mantles of dust-rich deposits are typical to these terrains.

2. Playa centers — areas where dust-sized materials accumulate through fluvial wash, differential transport and sorting. Takyr soils, which are composed mostly of silt and clay are derived from these deposits; eolian dust is added to the surface especially during periods of episodic ponding or wetting.

3. Gravelly terrains serve as efficient traps for dust due to their high surficial roughnes and porosity. Reg soils are soils with variable amounts of dust; the most developed are soils on Pleistocene coarse-alluvial surfaces . These usually include rather thick (5–30cm) gravel free A_v–B horizons. The C horizon is a gravel-rich layer with variable amounts of dust-sized fractions. Old Hammada soils are of similar nature. In certain cases the rate of dust accumulation may be especially high. An example is the Hammada soils on highly porous lava flows in the Cima Volcanic Field in the southern Mojave Desert, located downwind of extensive dust-producing playa surfaces. More than 1 m of a gravel-free B horizon has been developed during a period of less than 20,000 years (Wells et al., 1984).

4. Stable sandy terrains are good traps for settling dust. Sandy-loam and loam texture develop on such surfaces.

5. Other terrain types, such as hillslopes with Lithosols on them, carry varying amounts of dust.

Table E.2.1 and figures C1.16 and C.1.17 should be consulted for further information.

The Thickness Of The Dust-Rich Surficial Mantle

Since most of the dust in desert soils and surficial deposits was derived from the atmosphere, and was emplaced by pedogenic processes, there is a general tendency of high dust concentration to be near the surface and a lowering of the dust content with depth. However, there are terrains in which the accumulation of dust is continuous and the thickness of the dust-rich layer is considerable. Such are the cases of loessial terrains and Takyr soils, which may reach thickness of many meters of continuous silt and clay deposits and paleosols. In sand dune terrains there is sometimes a situation in which eolian sand and dust are added in low rates to a stabilised sand surface. The result is usually a thick layer of sandy-loam or loam. In Solonchak soils, being soils of poor pedogenic development in playas and sabkhas, there is also a significant element of accumulation. Under the rather shallow soils that are often encountered, similar such paleosols may be buried. The thickness data that are presented in column 4–5 of table E.2.1 for the above mentioned soils represent only the characteristic soil profile exposed at the surface in the Negev and the Sinai. Buried deposits and paleosols of similar nature should be considered.

Soils and deposits of non-cumulic nature present thickness according to their environmental conditions, such as climate — past and present, parent material, location and topography. As a general rule, the more arid the environment, the more shallow is the soil. In sites under extremly arid climates and/or of flat topography or in the upper parts of hillslopes, there is a low concentration of water and the penetration of dust and salts is rather shallow. Holocene Reg soils and young Hammada soils in the Negev and the Sinai are rather shallow — $\leq$50cm — since they have developed under arid to extremely arid conditions on flat to gently sloping geomorphic surfaces. Old (latest most Tertiary to late Pleistocene) gravelly soils on such surfaces are thicker and often attain depths of 140cm. Such soils have been during a part of their evolution under a moderately arid or a slightly wetter climate; the penetration of water, dust and salts has been deeper. Colluvial soils on foot-slopes and toeslopes may also be thicker than the soils on the upper parts of the hillslopes, due to both cumulic nature and the concentration of water from the backslope areas (Dan, 1966; Arsi, 1981).

On The Variability In The Amounts And Composition Of Dust In Desert Soils

The data in Table E.2.1 present a rather high degree of variability in dust and salts content, composition and thickness. The variability is reflected in four levels: (a) Between soil types. (b) Within a given soil type. (c) Between soil horisons in a given soil type. (d) In any particular soil horison in a given soil type.

Several topics are of interest in this respect: (a) The thickness of the soil profiles and soil horisons. (b) The proportion between gravel and fine earth materials (sand, silt and clay). (c) The content of dust (silt and clay) within the fine earth. (d) The content, composition and distribution of salt and gypsum in the soil.

There are many factors which cause the observed degrees of variability in the soil characteristics. These factors are discussed below; they have to be evaluated in conjunction with the data of Table E.2.1 (see elaboration in chapter E.1):

(a) **Local parent material strongly affects soil nature in deserts.** Two main soil groups may be defined: (1) Gravelly soils which develop in-situ within weathered hard rocks (Hammada soils) and coarse gravelly deposits (Reg soils). (2) Non-gravelly soils which develop on fine grained deposits (loessial soils, Takyr soils, sandy soils) and fine grained friable rocks (Lithosols). Porosity, permeability and trap efficiency are greatly affected by the texture and structure of the parent material.

(b) **Introduction of added — secondary — materials: dust, sand and salts.** Addition of autigenic materials into receptive parent materials or a trapping surface is dominant in the evolution of desert soils. Three aspects are significant in causing a high degree of variability in the nature of desert soils: (1) The composition of the introduced materials. One example is the change in the texture of loessial soils — sandy proximal to the provenance of sand (as in the westrern Negev; g in fig C.1.1A) and loamy, silty or clayey distal (and downwind) to sources of sand (c, d in fig. C.1.1A). (2) Mode and rate of introduction. This is affected by the porosity and permeability of the receptive parent materials and by the method of introduction — wet (by rain or wash) or dry (from windborne dust). The amounts and composition of the introduced materials vary greatly due to changes in the proportional activity of different processes. Widely open textured sieve deposits absorb dust in dry and wet modes to great depths, whereas coarse alluvium with sand is less penetrable. Dust accretion in gravelly environments in deserts is usually subsurface, whereas high rates of surficial accumulation are typical to loessial terrains in less arid environments and playa surfaces.

(c) **The effects of location and topography.** As in parent material, local changes in microtopography are most frequent in desert terrains. Their effects on the local hydrologic regime and trap efficiency for dust and salts are pronounced. They lead to high variability in dust and salt content and composition. One example of the variation is the dust content and salinity of Reg soils developed on coarse gravelly bars versus finer grained swales. The effects of such initial local features are observed in soils several 10^3 to few 10^5 years of age.

The effects of the aspect are readily observed in some soil types. Among those are the loessial soils, Serosem soils and Lithosols. The variation between differently exposed soils is expressed in soil depth, thickness of soil horisons, particle sise distribution and salinity. An example is the thin loessial Serosem soils on south-facing hillslopes versus thicker, less saline loessial soils on north-facing hillslopes in the northern Negev; the difference depends on both moisture regimes and vegetative cover on the respective hillslopes.

Some systematic variations in soil properties are found on certain landforms; zonation and catenary changes are observed. For example, there is a systematic variation in salinity in Reg soils on talus slopes from the upper to the lower slope components (table C.3.1). In playas there is a definite zonation with respect to particle size and salinity from the margins towards the center (plate 3B; figures C.1.3, C.3.3).

A major factor may be the proximity of a site to a certain source area for introduced materials – sand fields, sandstones, salt flats, etc.

(d) Climatic regimes and their changes. The effect of climate on the soil and deposits in the aridic environment is illustrated by the proportion of dust and coarser materials in the soils in the Negev (fig. C.1.1A,B). Loessial soils in the semi-arid northern Negev; Hammada and Reg soils in the arid - extremely arid central and southern Negev. The proportion between dust and gravel generally changes from the less arid northern Negev to the extremely arid southern Negev and eastern Sinai.

Climate is well expressed in soil salinity. An example is the degree of salinity and its distribution in loessial soils of the Negev (fig. C.3.1,2): the more arid the climate, the higher the salinity and shallower is the saline horizon.

Most Holocene and older soils have developed under an ever-changing climate; they are polygenetic in nature. Paleosols and paleosolic horizons are widespread and are certainly a major source of soil variability. The loessial soils of the northwestern Negev exhibit a sequence of paleosols in their cummulative section. Fig. C.1.15 illustrates the effects of fluctuating climate while loess was accumulating. The different climatic regimes are reflected by the change in soil texture as well as by the $CaCO_3$ content.

Most Reg soils on Pleistocene alluvial surfaces are relict paleosols, developed under fluctuating climatic regimes. Many of these soils have undergone environmental changes which include climates wetter than at present. The effects of these wetter regimes is expressed in both the thickness of the soil profiles (<1.4 m) and the relative abundance of fines.

(e) Age — the effect of time. The rate of evolution of some soil properties changes and usually decreases with time (Yaalon, 1971; Birkeland, 1974). Among the properties here examined are relative amounts of dust and salts in the fine earth fractions of the soil. Figures C.1.5,8 and C.3.6 illustrate several general trends for the example of Reg soils: (1) There is a general decrease in the percent of dust after several 10^3 years. (2) There is a very high variability in the content of dust in soil on any given pedomorphic surface. (3) There is a general increase in the rate after several 10^3 years. (4) There is a very high variability in the content of salts in the soil on any pedomorphic surface.

Rates Of Dust Accretion In Deserts — The Case Study Of The Negev

The rates of dust accretion in desert terrains is most variable. These rates depend on several factors:

1. The flux rate of airborne dust into the area under consideration. The flux rate is related to the type, proximity and direction of the source areas, as well as to the atmospheric circulation and wind speed and direction.

2. The nature of the airborne dust — particle size, composition and hygroscopy.

3. Climate — the regime of precipitation, air temperature, air humidity and winds.

4. The relief, gradient and aspect of the terrain.

5. The roughness of the surface, whi. effects dust settlement by determining boundary wind velocity (Gillette, 1981), rate of runoff and slopewash and surficial trapping of dust.

6. The hydraulic characteristics of the surficial material — porosity, pore size, pore relationships and permeability. Fluvial gravel and sieve deposits are example of highly porous and permeable materials.

The quantitative nature of some of these factors is not yet recognised and the effects of their combinations and interrelationships are not known. However, we have attempted to estimate the long term amounts of dust trapped at or near the surface and calculate the rates of dust accretion for two types of environments — desert soils and archeological sites.

Dust accretion is dependent on **trap efficiency**. Trap efficiency is defined here as the ratio between the flux rate of settling dust and the rate of dust accretion. The latter is defined as the long-term rate of deposition of dust at a particular site. Some sites have smooth surfaces as well as low porosity and permeablility; their trap efficiency is rather low. Other sites may have rough surfaces, low gradients or high porosity; their trap efficiency is high. There are terrains, such as loessial plains, in which dust is deposited mainly at the surface. Other terrains are characterised mostly by subsurface accretion; dust penetrates and builds subsurface cumulic horisons. Reg and Hammada soils are examples of this latter type.

In some cases there is a decrease of trap efficiency with time. Several factors lead to such a development:

1. A decrease of surficial roughness, which leads to a significant reduction of dust settlement and accretion. Surficial roughness may decrease through the deterioration of the vegetation (due to desertification), by filling of depressions by dust or by mechanical weathering of coarse gravel and smoothing of the surface into a desert pavement. The formation of smooth crusts is characteristic to several types of desert surfaces (see chapter C.4). Lesser amounts of dust are being added to smoother surfaces.

2. The accretion of dust and salts in shallow subsurface layers, as in the case of Reg soils, leads to decreasing penetration of dust and increasing runoff and surficial wash. Well developed Reg soils, with a smooth desert pavement — gravel with interstitial loess crust — overlying an argillic gravel-free B horison, induce high runoff yield and wash, as compared to less developed such soils (Grinbaum, in prep.)

The most rapid accretion, then, occurs on surfaces of high roughness and porosity, such as vegetated loessial terrains or young gravelly deposits. Most of the soils and the deposits described in the present study are of unknown age. However, several tens of the studied pedomorphic surfaces are dated or their age is estimated by archeologic finds or relative-age

dating methods (Amit & Gerson, 1985). Some surfaces or soils were dated radiometrically. The amounts of allochtonous dust and the age of the soil or the deposit enable us to present the rates of **dust accretion in some soils in the Negev:**

1. **Reg soils on early to middle Holocene alluvial surfaces** contain 10-20% of added airborne dust (see chapter C.1). Such a content implies average rate of accretion of 5-15 $gr/m^2/yr$, or 0.003-0.01mm/yr of dust. As emphasised above (and in chapter C.1) the rate of dust penetration decreases with time. This is manifested even during periods of $5 \cdot 10^3$ years (Amit & Gerson,1985). Dust accretion during the first period of several 10^3 years may be in the order of 0.5 mm/yr.

2. **Reg soils on alluvial surfaces of late Pleistocene and late middle Pleistocene** age contain variable amounts of dust, most of which is allochtonous. The content of added dust is 20-40%. Adopting an age estimate of $50\text{-}200 \cdot 10^3$ years for those soils yields an average of dust accretion of 1.5-15$gr/m^2/yr$, or 0.001-0.01 mm/yr. Again, much of dust was added to the soil in early stages of evolution, so that the actual rates may have been much higher.

3. **Stabilised sand dunes**, originally devoid of silt and clay, have trapped some 5-10% of dust to a depth of 30-50cm during the last several 10^3 years, an average rate of 0.001 mm/yr.

4. Thick **manties of loess and loessial soils** have developed in the northern and northwestern Negev during the middle and late Quaternary. There are three areas for which there is some information on the estimate of the rate of loess deposition: a. Netivot, which represents a vast area of the northwestern Negev . Data on loess thickness and age by Bruins (1976) yield average rates of 0.1mm/yr or 150$gr/m^2/yr$ of dust accretion. b. In the Ramat Hovav area, some 15 km south of Be'er Sheva , there are eolian loessial deposits that have accumulated at average rates of 0.1mm/yr (or 150$gr/m^2/yr$; Ensel, 1983) — similar to the rates calculated for the Netivot section (a, above). In these loessial terrains one observes several calcic horizons and changes in clay content, which may point at significant fluctuation in the rate of dust accretion during the late Quaternary. Climatic changes are also implied (see chapter E.1: On the Inpact of Climatic Fluctuations on Aridic Soils). c. More difficult is the evaluation of the average rates of dust deposition in some closed or "semi-closed" basins in the Negev , in which the loess was deposited by both fluvial and eolian agents. The dating of the deposits is also controvertial. One example is the basin of Sde Zin, in the northern central Negev. There, 5-10 m of fluviatile loess and loessial paleosols have accumulated during an estimated duration of several 10^5 years. Average net rates of loess deposition is estimated at 0.01-0.02mm/yr (or 15-30 $gr/m^2/yr$). It is possible that much of the section has been removed by erosion and deflation, especially during periods of arid climatic regimes.

The highest rates of dust depostion were calculated for **archeological sites in the Negev**, in which man-made structures — buildings and courtyards — serve as long-term dust traps. Such features usually have walls on all sides and are roofless. Originally they were unroofed or the roofs have collapsed a short time after abandonment. The walls are usually 1-1.5m high. Most of the buildings have a wall height:diameter (=horisontal extension) ratio of 1:3-1:5; they present a very high surficial roughness and serve as most efficient eolian dust traps. We have examined some twenty archeological sites across the Negev, from Tel Arad in the northeast to Biq'at Uvda in the south. The sites date from the 5th millenium B.P. (Early Bronse Age) to the 2nd millenium B.P.(Early Arabic Period). The buildings in all these sites are usually filled with dust and collapse stones up to 20-50 cm below the top of the wall remmants (plate 10). The ratio of dust: stones is variable — 1:1-4:1. Most of the buildings were

filled to capacity during a rather short period after abandonment, destruction or unroofing. At the early stages, when the building is deep (and especially if it is narrow), the accretion of dust is rapid since most of the settling dust remains in the building. The trap efficiecy decreases with time due to diminishing roughness; more and more of the arriving dust passes by. An equation that may be applied to this general trend should take into consideration (a) the initial depth of the structure, (b) the regime of airborne dust deposition (which includes the dust flux and the wind characteristics), (c) the shortening of the receptacle walls due to ongoing collapse, and (d) the time elapsing since the initiation of fill. $D_t=D_0(1-e^{-t/c})$ is such an equation, where D_t is the depth of accumulation at a point in time t, D_0 is the initial depth of the building, t is the time that elapsed since the beginning of fill and c is a constant depending on the regime of deposition. Most buildings were filled up during a period of 1,000–2,000 years. During this period some 20–50 cm of dust have accumulated. The average rate of accretion is 0.1–0.5 mm/yr (or 150–750 $gr/m^2/yr$). Based on the above considerations some 0.5–2.0 mm/yr is a reasonable estimate for the early stages of accretion , whereas after 1,000–1,500 years the rates of addition are very low. At a stage when the walls are 20–50 cm above the surface there is usually no accretion of eolian dust.

Present-day dust fall in the Negev and the Sinai ranges between 100 and 200 $gr/m^2/yr$ (Ganor, 1975), or 0.06–0.15mm/yr (see chapter B.7). These amounts are within the range of dust accretion calculated for highly efficient dust traps of the past — late Pleistocene loessial terrains in the northwestern Negev and archeological sites. Most of the dust that falls on other types of terrains is not trapped; it resumes eolian transport or is washed by runoff. Only in cases of very large flux rate of dust onto areas of extremly high porosity there is a rapid rate of subsurface dust accretion. One example is the Cima Volcanic Field in the southern Mojave Desert (Wells et al., 1984). The area is located downwind of playas and dried lakes which served as major sources of dust to adjacent sites. There, thick Hammada soils have developed; a 1.0m thick gravel-free dust layes underlying a desert pavement, has developed during a period of $16.6–19 \cdot 10^3$ years, indicating an average rate of dust accretion of $92gr/m^2/yr$.

Summary — Rates Of Accretion

1. The rates of eolian dust accretion in the semi-arid northern Negev during the late Quaternary were similar to the present-day dustfall in this area — 0.5–0.15mm/yr.

2. The accretion of dust in most desert gravelly soils is usually a portion of the dustfall. Averages of 0.003–0.01 during the Holocene and 0.001–0.01 during the middle and late Pleistcene were calculated.

3. Trap efficiency for dust in gravelly soils decreases rapidly with time, due to the sealing effect at the surface and plugging of the pores in the soil profile by dust.

4. There are indicators that the flux rates of eolian dust have fluctuated greatly during the Quaternary: a. Loessial paleosols change significantly in nature in cumulative uninterrupted sections. b. In many areas there has been an extensive deposition of loess during the late Pleistocene whereas the Holocene (late Holocene ?) was a period of net degradation. c. There is evidence that at the thick (> 1.0m) Reg soils on Pleistocene alluvial surfaces have developed during a rather short period of time of several 10^4 years. Most of the dust and salts in these argillic and saline soils may have been added during periods of large import of airborne materials.

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PART G. APPENDICES

G.1 METHODS

Introduction

Some 200 soil profiles and depositional sections were described, sampled and analysed. Most of the soil profiles and the depositional sections were described, sampled and analysed by the authors. Some soil profiles, in the northern Negev, the Judean Desert and the Jordan Valley were treated by other workers (see references in Part F and table G.3.2). Fig. A.1 serves as a location map for the profiles from which the various data were derived.

Field Methods

Description of the soil profiles and the depositional sections was carried out according to Dan et al.(1964), Birkeland (1974) and Soil Survey Staff (1975). Abbreviated and simplified descriptions of selected profiles are presented in Appendix G.2. Most of the soil pits were hand-dug, some were dug by back hoe and other sections were found along road cuts and stream banks.

Every soil horison and layer of deposit was described. The content of the fine earth and the amounts of gravel were noted in the field. Samples of 400–800 gr were collected for laboratory analysis.

Laboratory Analysis

The analysis of the samples was conducted along two lines:

1. **Particle sise.** Dry sieving was employed for the separation of gravel from the finer fraction (<2mm). Wet sieving was employed for the separation of gravel and dust from the sand and the fractionation of the latter. The pipette method was used for the silt-clay fraction. 1 ϕ intervals were determined. Calgon ($Na_4O_7P_2$) was used for dispersion.

2. **Salinity and salt composition.** Electrical conductivity was carried out on water extract of the 1:1 soil:water samples of the fine earth fraction. The content of gypsum was determined using Schleiff's (1979) methods, using the change of electrical conductivity in samples of fine earth having different soil:water ratios. Cl^- was determined by a chloridometer and an ICP (induced coupled plasma) apparatus. The content of Na^+, K^+, Ca^{++}, and Mg^{++} in the soluble salts was determined by atomic absorption spectrophotometry.

Data Organisation and Analysis

The information on every sample was rated according to the following groups of data:

1. Geographical data, such as coordinates, location.

2. Climatic data, such as mean annual precipitation.

3. Physiographic definition, such as landform type and relief.

4. Soil type and age.

5. Sise fractions — gravel, sand, silt, clay, silt/clay ratio.

6. Salt content and ratios: soluble salts, gypsum, salt/gypsum ratio.

7. Composition of soluble salts — Cl^-, Na^+, K^+, Ca^{++}, Mg^{++}.

The data were processed and analysed statistically, employing BMDP and SPSS computer programs for documentation, correlation and multivariate examination.

G.2 SELECTED SOILS AND DEPOSITS — DESCRIPTIONS

1 Loessial Soil

Northwestern Negev — Netivot

	depth,cm	
A	0- 30	Silty clay loam; fine crumb to slightly massive structure; 1% carbonate nodules; yellowish brown 10YR5/4 dry, 9YR4/4 dry; gradual and smooth boundary.
AB	30- 58	Silt loam; massive to subangular blocky structure; 1% carbonate nodules; light yellowish brown 10YR6/4 dry, yellowish brown 10YR5/4 wet; abrupt, smooth boundary
B_{bca}	58- 85	Silty clay; medium prismatic structure; 7% carbonate nodules; dark brown to brown, 7.5YR4.5/4 dry, 7.5YR4/4 wet; gradual and wavy boundary.
B_{bca}	85-100	Silty clay; prismatic to brittle angular blocky structure; 5-20% carbonate nodules; brown 7.5YR5/4 dry, brown to dark brown 7.5YR4/4 wet; gradual and wavy boundary.

2 Loessial Soil

Western Negev

	depth,cm	
A	0- 40	Fine loamy sand; massive structure; friable; light yellowish brown 10YR6/4 dry, dark yellowish brown 10YR4/4 wet; gradual boundary.
B	40- 77	Fine loamy sand to loam; some carbonate mycelia; fine subangular blocky structure; friable to hard; light yellowish brown 10YR6/4 dry, yellowish brown 10YR5/4 wet; gradual boundary.
B	77-112	Similar to above layer; masive to unstable subangular structure; gradual boundary.
B_b	112-130	Similar to above layer; loam with some carbonate concretions; abrupt boundary.
B_b	130-158	Silt loam to silty clay loam; some carbonate concretions (5%) 1 cm in diameter; medium subangular blocky structure; hard; yellowish brown 10YR5/4 dry, dark yellowish brown 10YR4/4 wet; gradual boundary.
B_b	158-180	Loam; some carbonate concretions 1 cm in diameter; massive structure; hard; yellowish brown 10YR5/4 dry, dark yellowish brown 10YR4/4 wet; abrupt boundary.
B_b	180-210	Loam to sandy clay loam; hard and soft carbonate concretions (-25%) 5-10 cm in diameter; massive structure; hard; some roots; light yellowish brown 10YR6/4 dry, dark yellowish brown 10YR4/4 wet.

3 Loessial Soil **Western Negev**

	depth,cm	
A_1	0- 28	Sandy loam; massive structure; crumby; yellowish brown 10YR5/4 dry, dark yellowish brown 10YR4/4 wet; gradual boundary.
A_3	28- 70	Sandy loam; light yellowish brown 10YR6/4 dry, yellowish brown 10YR5/4 wet; gradual boundary.
C_1	70- 97	Sandy loam; some carbonate concretions; yellowish brown 10YR5/5 wet; gradual boundary.
C_1	97-144	Sandy loam to loamy sand; carbonate concretions (-2%); hard; abrupt boundary.
C_1	144-160	Loamy sand; more carbonate concretions (-5%); abrupt boundary.
C_2	160-200	Sandy loam to loamy sand; carbonate concretions (-1%).

4 Brown Loessial Soil **Western Negev**

	depth,cm	
A 0	- 20 Silt	loam; granular blocky to subangular blocky structure; hard; hard; light yellowish brown to yellowish brown 10YR5.5/4 dry, dark yellowish brown 10YR4/4 wet; gradual boundary.
A	20- 52	Loam — similar to above layer; massive to subangular blocky structure; hard; abrupt boundary.
B_{ca}	52-96	Fine loamy sand; soft carbonate concretions 0.5-1cm in diameter; thin medium subangular blocky structure; light yellowish brown 10YR6/4 dry, yellowish brown 10YR5/4 wet; gradual boundary.
C_1	96-120	Similar to above layer; less (5%) carbonate concretions; massive to subangular blocky structure; gradual boundary.
C_2	120-150+	Similar to above layer with few carbonate concretions.

5 Brown Loessial Soil **Western Negev**

	depth,cm	
A	0- 42	Silt loam; massive structure; contains carbonate; pale brown 10YR6/3 dry, yellowish brown 10YR5/4 wet; clear abrupt boundary.
B_{ca}	42- 78	Silt loam; many (20%) carbonate concretions; thin medium subangular blocky structure; hard; light yellowish brown 10YR6/4 dry, yellowish brown 10YR5/4 wet; gradual boundary.

C_1	78-101	Similar to above layer; about 5% carbonate concretions; gradual boundary.
B_b	101-160	Loam; 10-15% carbonate concretions; prismatic crumb structure; hard; 9YR5/6 dry, dark yellowish brown 10YR4/4 wet.

6 Brown Loessial Soil — **Western Negev**

	depth,cm	
A	0- 44	Loam; massive structure, not sticky; hard; yellowish brown 10YR5/4 dry, dark yellowish brown 10YR4/4 wet; gradual boundary.
B_1	44- 67	Similar to above layer; weak subangular blocky structure; about 5% soft carbonate concretions 0.5-1cm in diameter; gradual boundary.
B_{2ca}	67- 88	Loam to clay loam; 10% - 15% soft carbonate concretions 0.5-1cm in diameter; hard; yellowish brown 10YR5/4 dry, dark yellowish brown 10YR4/4 wet; gradual boundary.
BC	88-116	Silt loam; 5% soft carbonate concretions 0.5-1cm in diameter; thin medium subangular blocky structure; light yellowish brown 10YR6/4 dry, yellowish brown to dark yellowish brown 10YR4.5/4 wet; gradual boundary.
C	116-160	Similar to above layer; fine loamy sand; 2% carbonate concretions; massive structure.

7 Light Brown Loessial Soil — **Western Negev**

	depth,cm	
A	0- 28	Loamy sand; massive to loose; some hard carbonate nodules; light yellowish brown 10YR6/4 dry, dark yellowish brown 10YR4/4 wet; abrupt boundary.
B_{2ca}	28- 45	Loamy sand; petrocalcic horizon (70%); massive structure; hard; pink 7.5YR7/4 dry, strong brown 7.5YR5/6 wet; gradual boundary.
B_{3ca}	45- 65	Similar to above layer without petrocalcic horizon; hard carbonate nodules (-40%); hard; gradual boundary.
BC	45- 90	Sandy loam; hard carbonate nodules (-5%); massive structure; hard; light brown 7.5YR6/4 dry, strong brown 7.5YR5/6 wet; gradual boundary.
C_1	90-130	Sand to sandy loam; hard carbonate nodules (1-3%); light brown 7.5YR6/4 dry, strong brown 7.5YR5/6 wet; gradual boundary.
C_2	130-200	Sand; loose; pink 7.5YR7/4 dry, strong brown 7.5YR5/6 wet.

8 Light Brown Loessial Soil **Western Negev**

	depth,cm	
A	0- 30	Loamy sand; hard; very pale brown 10YR7/3 dry, yellowish brown 10YR5/5 wet; gradual boundary.
B_{2ca}	30- 80	Loamy sand; carbonate nodules (5–10%) some hard; hard; light yellowish brown 10YR6/4 dry, yellowish brown 10YR5/6 wet; gradual boundary.
B_{3ca}	80-118	Sandy loam; carbonate nodules (-20%) 10–20cm in diameter; friable; wavy boundary.
C	118-210	Sand; massive structure; hard carbonate concretions (10–20%); loose; very pale brown 10YR7/4 dry, yellowish brown 10YR5/6 wet.

9 Light Brown Loessial Soil **Northern Negev — Sde Boker**

	depth,cm	
A	0- 8	Clay loam; crumb structure; many roots; very pale brown 10YR7/4 dry, light yellowish brown 10YR6/4 wet; gradual boundary.
B_1	8- 20	Clay; gypsum nodules; hard; very pale brown 10YR7/4 dry, light yellowish brown 10YR6/4 wet; gradual boundary.
B_{2ca}	20- 40	Clay; gypsum nodules (15–20%); hard; very pale brown 10YR7/4 dry, light yellowish brown 10YR6/4 wet; gradual boundary.
C_{ca}	40- 65	Heavy clay with gravel; carbonate nodules (-35%); hard blocky structure; very pale brown 10YR7/4 dry & wet.

10 Loessial Serosem **Western Negev**

	depth,cm	
A	0- 12	Fine loamy sand; contains carbonates; massive structure; slightly hard; very pale brown 10YR7/3 dry, light yellowish brown 10YR6/4 wet; abrupt boundary.
B_{1ca}	12- 33	Loam; carbonate nodules (-25%); Subangular blocky to blocky structure; hard; light yellowish brown 10YR6/4 dry, yellowish brown 10YR5/6 wet; gradual boundary.
B_{2sa}	33- 61	Silt loam; carbonate nodules (-25%), with gypsum or salt vertical mycelia; blocky structure; hard; light yellowish brown 10YR6/4 dry, yellowish brown 10YR5/4 wet; gradual boundary.
B_{3ca}	61- 91	Similar to above layer with many salt and gypsum mycelia; blocky structure; gradual boundary.
$B_{b3ca,sa}$	91-141	Silt loam to clay loam; blocky structure; yellowish brown 10YR5/4 dry, dark yellowish brown 10YR4/4 wet; gradual boundary.

$B_{B3ca,cs}$	141-191	Similar to above layer; blocky to prismatic structure; continues to a great depth.

11 Loessial Serosem Soil — Northern Negev — Sde Boker

	depth,cm	
A	0- 17	Clay loam with about 10% pebbles 1-3cm in diameter; crumb structure; friable; many roots; very pale brown 10YR7/4 dry, light yellowish brown 10YR6/4 wet; gradual boundary.
B_1	17- 40	Clay loam to silty clay loam, with about 10% pebbles 3-4cm in diameter; subangular blocky to hard blocky structure; carbonate pseudomycelia; fine roots; very pale brown 10YR7/4 dry & wet.
B_2	40- 60	Silty clay loam with about 10 % pebbles 1-3cm in diameter; carbonate nodules (5%); subangular blocky to blocky structure; very pale brown 10YR7/4 dry & wet.
B_{2ca}	60- 78	Silty clay loam with few cobbles 20-30cm in diameter; carbonate nodules (3-5%) 5mm in diameter and few gypsum crystals; subangular blocky to blocky structure; friable; very pale brown 10YR7/4 dry & wet.
$B_{2cs,ca}$	78-100	Silty clay loam with 5-10% pebbles 1-3cm in diameter; carbonate nodules (5%) 10-15mm in diameter and gypsum crystals (-5%); blocky structure; pale brown 10YR6/3 dry & wet.

12 Loessial Serasem Soil — Northen Negev — Sde Boker

	depth,cm	
A	0- 12	Clay loam; loose; few roots; very pale brown 10YR7/4 dry, light yellowish brown 10YR6/4 wet; gradual boundary.
B_1	12- 25	Clay loam with few pebbles 1-3cm in diameter; carbonate pseudomycelia and carbonate nodules 2-3cm in diameter; subangular blocky to massive structure; friable; very pale brown 10YR7/4 dry, light yellowish brown 10YR6/4 wet; gradual boundary.
B_2	25- 45	Clay loam with few pebbles max. 5cm in diameter; about 3% carbonate nodules 5mm in diameter and abour 3% gypsum nodules; subangular blocky to blocky structure; hard; light yellowish brown 10YR6/4 dry, yellowish brown 10YR5/4 wet; gradual boundary.
$B_{3cs,ca}$	45- 65	Clay loam with about 25% gravel 2-8cm in diameter; few carbonate nodules and gypsum mycelia 5mm in diameter; subangular blocky structure; friable; very pale brown 10YR7/4 dry, light yellowish brown 10YR6/4 wet; gradual boundary.

$B_{3cs,ca}$	85-130	Clay loam with about 15% gravel max. 8cm in diameter; 10–40% carbonate hodules 5–3 omm in diameter, some gypsum mycelia; blocky structure; friable; very pale brown 10YR7/4 dry, light yellowish brown 10YR6/4 wet; wavy gradual boundary.

13 Loessial Serosem Soil — Northen Negev — Sde Boker

	depth,cm	
A	0- 22	Loam; strong, medium to fine subangular blocky structure; very pale brown 10YR7/3 dry, light yellowish-brown 10YR6/4 wet; clear boundary.
B_{1cs}	22- 35	Similar to above layer with many white mottles (1mm) of crystalline salt and gypsum; clear boundary.
B_{2ca}	35- 70	Silty clay loam with 50 % white lime nodules (2cm), mostly elongated vertically; medium blocky to prismatic structure; very hard; brown 7.5YR4.5/5 dry, dark brown 7.5YR4/4 wet; clear to gradual boundary.
B_3	70- 82	Silty clay loam with few white lime flecks and small black mottles; medium blocky parting into strong fine blocky structure; strong brown 7.5YR5/6 dry & wet; clear to gradual boundary.
C_1	82-132	Silty clay loam with few sand and gypsum crystals; massive to weak subangular blocky structure; hard; light yellowish brown 10YR6/4 dry, yellowish brown 10YR5/4 wet; smooth clear boundary.
B_b	132-165	Loam to clay loam with 50% lime flecks and many gypsum crystals, mostly in thick mycelia; moderate fine blocky to subangular blocky structure; very hard; reddish yellow to yellowish brown 6YR5/6 dry & wet; the same layer continues to greater depths.

14 Loessial Serosem Soil — Judean Desert — Rujm a Naqua

	depth,cm	
A_0		Cover of some stones and lot of gravel.
A	0- 15	Calcareous loam; massive; slightly hard; light yellowish brown 10YR6.5/4 dry, yellowish brown 10YR5/6 wet; clear boundary.
B_{1ca}	15- 40	Calcareous silt loam with 20% soft carbonate nodules (1 cm); moderate fine subangular blocky structure; harde; light yellowish brown 10YR6/4 dry, yellowish brown 10YR5/4 wet; gradual boundary.
B_{2ca}	40- 68	Silty clay loam with 30–40% soft lime nodules (1 cm); strong subangular blocky structure; hard; brown 7.5YR5/4 dry, 7.5YR4.5/4 wet; gradual boundary.

B_{2}	68-107	Calcareous silty clay loam with 20% soft lime nodules (1 cm); strong medium to fine subangular blocky structure; hard; light brown 7.5YR6/4 dry, brown 7.5YR5/4 wet; gradual boundary.
B_{3cs}	107-150	Calcareous silty clay loam with 10% soft lime nodules and some clusters of gypsum crystals; moderate medium to fine subangular blocky structure; hard; brown 7.5YR7/4 dry & wet; gradual boundary.
B_{bcs}	150-180	Calcareous silty clay loam with very few (2%) soft lime nodules and many mycelia and clusters of crystattine gypsum; weak; medium to fine subangular blocky structure; slightly hard; brown 7.5YR5/4 dry & wet.

15 Loess — Archaeological Site **Central Negev — Makhtesh Ramon**

depth,cm	
0- 10	Shattered grit with silt (15-30%) and pebbles (max. 6cm); light yellowish brown to brownish yellow 10YR6/4-6 dry, yellowish brown 10YR5/6 wet.
10- 30	Silt(60%) with sand and grit; some pebbles; brownish yellow 10YR6/6 dry, yellowish brown 10YR5/6 wet.
30- 55	Boulders (max. 30-40cm); some shattered; boulders coated with salts; brownish yellow 10YR6/6 dry, dark yellowish brown 10YR4/6 wet.
55- 60	Silt with shattered pebbles; brownish yellow 10YR6/6 dry, yellowish brown 10YR5/8 wet.
60- 75	Silt and grit; small nodules of gypsum and salt; pale yellow 2.5YR8/4 dry, olive yellow 2.5YR6/8 wet.
75- 85	Silt with small pebbles (1 cm) and some sand; very pale brown 10YR7/4 dry, yellowish brown 10YR5/6 wet.

The profile contains -80% fine earth, down to 60cm it contains 60% fine earth.

16 Loess — Archaeological Site **Southern Negev — Uvda Valley**

depth,cm	
0- 5	Silt with fine sand, without stones, yellow 10YR7/6 dry, brownish yellow 10YR6/6 wet.
5- 15	Similar to above layer.
15- 20	Silty layer; yellow 10YR7/6 dry, yellowish brown 10YR5/6 wet.
20- 40	Silt with fine sand.

17 Takyr Soil — **Southern Negev — Shaḩrut Valley**

	Depth, cm	
A_1	0- 30	Silt; massive to flaky structure; yellow 10YR7/6 dry, brownish yellow 10YR6/8 wet.
C_1	30- 40	Silt; flaky structure; porous.
C_2	40- 43	Silt; flaky structure; reddish yellow 7.5YR7/6 dry, reddish yellow 7.5YR6/6 wet.
C_2	43- 45	Silty crust; hard; light color.
C_2	45- 48	Silt; flaky structure; porous; dark color.
C_2	48- 50	Silt crust; hard.
C_2	50- 70	Silt; yellow 10YR7/6 dry, brownish yellow 10YR6/8 wet.

Carbonate flecks throughout the profile.

18 Takyr Soil — **Southern Negev — Qa En Naqb**

	depth,cm	
A_0	0-0.3	Light silty crust; cohesive; laminar structure.
A_1	0.3- 12	Fines; crumb structure; salt and gypsum nodules.
$C_{cs,sa}$	12- 50	Fines; friable and loose; salt and gypsum nodules.
$C_{cs,sa}$	50-	80+ Fines; gypsum nodules.
		The color of the profile: brownish yellow 10YR6/8 dry, reddish yellow to strong brown 7.5YR6-5/6 wet. The profile is 100% fine earth.

19 Takyr Soil — **Southern Negev — Qa En Naqb**

	depth,cm	
A_1	0- 5	Silty clay crust; massive with some pores in the lower part; extremely hard; pink 7.5YR7/4 dry, strong brown 7.5YR4.5/6 moist; abrupt boundary.
A_2	5- 10	Similar to above layer, with massive to platy structure; hard; abrupt boundary.
$B_{2cs,ca}$	10-	20 Saline silty clay with small white mottles of gypsum; subangular blocky structure; slightly hard; light brown 7.5YR6/4 dry, strong brown 7.5YR4/6 moist; gradual boundary.
B_3	20- 26	Similar to above layer, less gypsiferous; gradual boundary.
C	26- 60	Similar to above layer; coarser textured, especially down to 40cm.

20 Takyr Soil — **Eastern Sinai — Wadi Mukeibila**

Horizon	depth,cm	Description
A_1	0- 4	Fines; laminar structure; cracked surface.
C_1	4- 14	Silty clay; without stones or salt.
C_2	14- 60	Similar to the above horizon.

21 Solonchak Soil — **Eastern Samarian Desert — Ma'ale Efraim**

Horizon	depth,cm	Description
A_0		Some gravel and stones are seen on the surface.
A_1	0- 13	Calcareous clasy loam to silty clay loam; weak fine subangular blocky to granular structure; soft; light brown 7.5YR6/4 dry, brown to dark brown 7.5YR4/4 wet; gradual boundary.
A_3	13- 30	Calcareous clay loam to silty clay loam; moderate, medium to fine subangular blocky structure; loose; brown 7.5YR5/4 dry, brown to dark brown 7.5YR4/4 wet; smooth, clear boundary.
B_2	30- 60	Calcareous silty clay with few lime spots; very coarse columnar structure; extremely hard; brown 7.5YR5/4 dry, brown to dark brown 7.5YR4/4 wet; gradual boundary.
B_2	60-100	Calcareous silty clay with soft lime flecks that increase gradually with depth; medium prismatic to blocky structure; extremely hard; brown to reddish brown 6YR4/4 dry and moist; indistinct boundary.
B_{2ca}	100-120	Similar silty clay with many soft lime flecks (20%); reddish brown 5YR4/4 dry and wet.

22 Solonchak Soil — **Dead Sea — Ein Tamar**

Horizon	depth,cm	Description
	0- 2	Saline crust with many large gypsum crystals; massive; hard; underneath the crust many large salt crystals; light grey 10YR7/2 dry, pale brown 10YR6/3 wet; abrupt boundary.
	2- 14	Fine sand loam with many gypsum crystals (0.5 cm) and with a grey silt loam layer with rusty motles (30%) at depth of 9-12cm; yellowish brown 10YR5/4 wet; clear boundary.
	14- 33	Silt loam with 10-15% large rusty mottles (1 cm) and a few large gypsum crystals; massive; hard; pale yellow 5YR7/3 dry, light browninsh grey 2.5YR6/2 wet; gradual boundary.
	30- 74	Silty clay loam wuth a few large gypsum crystal; massive; hard; white 2.5YR8/2 dry, light brownish grey to light yellowish brown 2.5YR6/3 wet; clear boundary.

	74-110	Silty clay loam with a few rusty motled, a few gypsum crystals and 5-6 thin (2.5mm) black layers; massive; very hard; white 2.5YR8/2 dry,light brownish grey to light grey 2.5YR6.5/2 wet; clear boundary.
	110-130	Silty clay loam; hard; white 2.5YR8/2 dry, light grey 2.5YR7/2 wet; gradual boundary.
	130-160	Similar to above layer with a few rusty mottles (0.5-1cm); indistinct boundary.
	160-210	Similar to above layer, but with silt loam texture and fewer rusty mottles.

23 Solonchak Soil — Southern Arava — Avrona Playa

	depth,cm	
A_0		Friable sandy crust with some gravel.
	0- 3	Salt with some sand; slightly hard; wavy layer; strong brown 7.5YR5/6 wet.
	3- 10	Sand and silt; massive; some salt crystals.
	10- 12	Silt and clay; very hard; discontinuous layer; laminar structure; reddish yellow 7.5YR7/6 dry, brown to strong brown 7.5YR5/4-6 wet; wavy boundary.
	12- 20	Sand and silt; salt crystals; very hard; redish yellow 7.5YR7/6 dry, brown to strong brown 7.5YR5/4-6 wet, clear wavy boundary.
	22- 30	Similar to layer 12-20.
	30- 45	Sand and silt with some thin laminae of small pebbles and granules (average 0.5cm, max. 1.5cm in diameter); gypsum crystals in large quantity; yellowish res 5YR5/6 wet.
	45- 60	Sand with some silt and granules; salt crystals.
	60- 80	Sand with some silt and granules; salt; crystals; massive; brown to strong brown 7.5YR5/4-6 wet.

24 Solonchak Soil — Eastern Sinai — Bir Sweir

	depth,cm	
A	0- 2	Silty clay cust covers the surface (dry).
$C_{1sa,ca}$	2- 30	Sandy loam with yellow and red mottles; some salt flecks.
$C_{2ca,sa}$	30- 55+	Sandy loam, large quantity of neddle like salt crystals; yellowish red 5YR5/8 wet.

25 Alluvium — **Dead Sea — Nahal Ze'elim**

depth,cm	
0- 2	Gravel, without fines.
2- 7	Gravel 2–3cm in diameter with fines.
17- 25	Gravel 5–10cm in diameter with fines.
25- 50	Some boulders with gravel and fines.

26 Alluvium — **Southern Negev — Uvda Valley**

depth,cm	
0- 5	Fine sand and silt compact firmly; subdivided into a silty hard crust down to 1cm, slightly loose silt and fine sand down to 5cm; yellow 10YR7/8 dry, brownish yellow 10YR6/8 wet.
5- 15	Calcareous silt; hard; yellow 10YR7/6 dry, brownish yellow 10YR67/6 wet.
15- 20	Fine sand and silt; friable of low consistency; yellow 10YR7/6 dry, brownish yellow 10YR6/8 wet.
20- 25	Fine sand; hard; yellow 10YR7/6 dry, yellow 10YR7/8 wet.
25- 33	Silty; thin laminar bedding, yellow 10 YR7/6 dry, brownish yellow 10YR6/8 wet.
33- 35	Silty; very hard.
35- 40	Coarse sand with quarts grit; friable and very loose; fluvial sand; yellow 10 YR7/6 dry, yellow 10YR7/8 wet.
40- 50	Fine sand; laminar; friable.

27 Alluvium — **Eastern Sinai — Wadi Mandara**

depth,cm	
surface	Bar and swale patern cover the surface; white color.
0- 60	Sand and grit laminae.

28 Alluvium — **Central Sinai — Bir - eth Thamada**

	depth,cm	
A	0- 10	Loamy sand with about 50% pebbles; loose; very pale brown 10YR7/4 dry, light yellowish brown 10YR6/4 wet; abrupt boundary.
AC	10- 24	Loamy sand with about 10% pebbles; clear abrupt boundary.
C_1	24- 40	Sand to sandy loam with about 70% pebbles; clear abrupt boundary.

C_1	40- 56	Sand with some (10%) pebbles; clear boundary.
C_1	56-110	Sand with about 70% pebbles.

29 Reg Soil, Holocene — **Dead Sea Valley — Nahal Ze'elim**

	depth,cm	
A_0		Desert pavement covers 90–95% of the surface; well sorted gravel 2–10cm in diameter.
A_v	0-0.5	Vesicular layer; silty; very pale brown 10YR7/3 dry, light yellowish brown 10 YR6/4 wet; clear boundary.
B	0.5-4.5	Silty clay with pebbles of average 1cm in diameter; some gypsum nodules; reddish yellow 7.5YR7/6 dry, reddish yellow 7.5YR6/6 wet.
C	4.5-35.5	Poorly sorted gravel; 70% of the gravel is shattered; white friable gypsum nodules; very pale brown 10YR7/4 dry, light yellowish brown 10YR6/4 wet.

30 Reg Soil, Holocene — **Southern Negev — Wadi Paran**

	depth,cm	
A_0		Desert pavement covers 95–100% of the surface; well sorted pebbles, average 2.5cm in diameter.
A_v	0-0.3	Vesicles underneath the stones; wavy boundary.
B	0.3- 10	Small pebbles (1cm in diameter); some shattered; gypsum crystals; -30% fine erth; yellow 10YR7/6 dry, brownish yellow 10YR6/8 wet.
B_{cs}	10- 17	Petrogypsic horizon, highly cemented with some shattered gravel.
C_1	17- 40	Gravel, poorly sorted; average 2cm in diameter, max. 7cm; shattered; some granules; very loose; salts cover many stones and cracks; some gypsum nodules; -10% fine earth.
C_1	40- 55	Similar to above layer; rounded cobbles 8–10cm in diameter, only the big pebbles are shattered; without salt crystals.

31 Reg Soil, Holocene — **Southern Negev — Timna Valley**

	depth,cm	
A_0	0- 2	Desert pavement mixed with fines; bar and swale pattern.
A_v	2-3.5	Silty; vesicular layer; light brown 7.5YR6.5/4.
B	3.5- 6	Silty; yellowish red 5YR4.5/6.
C_1	6- 9	Fines with some small pebbles.
C_1	9- 14	Shattered small pebbles.
C_1	14- 40	Pebbles with fines; well sorted.

32 Reg Soil, Holocene — **Eastern Sinai — Wadi Mukeibila**

	depth,cm	
A_0		Desert pavement covers 98% of the surface. Clear bars with unsorted boulders (80cm in diameter), gravels mixed with sand.
A_1	0- 2	Thick, vesicular layer, with relatively large vesicules; hard; some small stones near the boundary; very pale brown 10YR 7/4 dry, light yellowish brown 10YR6/4 wet; clear smooth boundary.
B_1	2-3.5	Coarse sand with grit; continous layer; reddish yellow 5YR6/8 dry, yellowish red 5YR5/7 wet; clear boundary.
B_{cs}	3.5- 12	Sandy; some poorly sorted stones and gravel (max.6cm); concentration of gypsum mycelia around the stones; gravel and stones are shattered; pink 7.5YR 7/4 dry.
C_1	12- 46	Sandy; poorly sorted pebbles and cobbles; some crystalline salt around the bottom of gravels.

33 Reg Soil, Holocene — **Eastern Sinai — Wadi Khuweit**

	depth,cm	
A_0		Desert pavement covers 85-90% of the surface; poorly sorted gravel.
A_1	0- 3	Silty; powdery fines; small vesicles 0.5-1mm; loose; reddish yellow 7.5YR8/6 dry, 7.5YR7/8 wet; abrupt boundary.
BC	3- 6	Silt with granules and small pebbles; very loose; reddish yellow 7.5YR7/8 dry, 7.5YR6/8 wet, abrupt boundary.
C_1	6- 30+	Sediments; very loose.

The profile contains 5-10% fine earth.

34 Reg Soil, Pleistocene — **Central Negev — Makhtesh Ramon**

	depth,cm	
A_0		Desert pavement covers the surface; very poorly sorted gravel-pitted, average of 40cm in diameter.
A_v	0- 3	Vesicular layer; very small vesicles; yellow 10YR7/6 dry, brownish yellow 10YR6/8 wet; abrupt boundary.
B_1	3- 13	Gravel free horison; friable carbonate nodules; yellow 10YR7/8 dry, brownish yellow 10YR6/8 wet.
C_1	12- 20	Shattered gravel; carbonate nodules.
C_2	20- 50	Small unshattered gravel; friable gypsum nodules bridge between the stones.

The profile contains -40-50% of fine earth.

35 Reg Soil, Pleistocene — **Central Arava Valley — Hatzeva**

	depth,cm	
A_0		Rock fragments cover the surface — desert pavement.
A	0- 1	Sandy loam with some pebbles; very pale brown 10YR7/3 dry, light yellowish brown 10YR6/4 wet; clear boundary.
B_{2sa}	1- 5	Loam-clay loam; 20% of pebbles, salts; loose; reddish yellow 7.5YR6/6 dry, strong brown 7.5YR5/6 wet; clear wavy boundary.
B_{2cs}	5- 12	Fines with some pebbles; gypsum crystals; wavy boundary.
B_{3sa}	12- 20	Silt and sand with 30% pebbles; white salt spots; loose; light broiwn to light yellowish brown 9YR6/4 dry, strong brown 7.5YR5/6 wet; clear to gradual boundary.
$C_{1cm,cs}$	20- 39	Petrogypsic horison partly cemented;sand and silt with gravel; massive; hard; white 10YR8/1 dry, very pale brown 10YR7/3 wet; gradual boundary.
C_1	39- 52	Sand with 50% pebbles; gypsum crystals; massive; loose; very pale brown 10YR7/3 dry, very pale brown to light yellowish brown 10YR6.5/4 wet; gradual boundary.
C_{1cs}	52-100	Similar to above layer; more gypsum crystals; gradual boundary.
C_1	100-117	Similar to above layer; number of gypsum crystals decrease with depth.
C_2	117-135	Similar to above horison.

36 Reg Soil, Pleistocene — **Southern Negev — Wadi Paran**

	depth,cm	
A_0		Desert pavement covers 95% of the surface; well sorted pebbles with (-10%) rounded cobbles 15cm in diameter.
A_v	0-0.3	Vesicles coating the bottom of stones.
B	0.3- 11	Fines with very little stones; powdery small gypsum crystals; loose; 30% fine earth; brownish yellow 10YR6/8 dry, yellowish brown 10YR5/8 wet; wavy boundary.
C_1	11- 50	Shattered gravel; 50% of the gravels are cobbles averaging 1 0cm in diameter; pebbles of 2cm in diameter and some granules; mottles of gypsum max. 4cm in diameter; salt crystals cover many stones and sometimes bridge between them; -25% fine earth; reddish yellow 7.5YR7/6 dry, brownish yellow 10YR 6/8 wet.
C_2	50- 65	Pebbles and granules, average 0.5-1cm in diameter max. 5-7cm; massive structure; some crystalline gypsum; salts at the bottom of stones; -10% fine earth; hard-cchessive.

C_s	65- 95	Gravel - rounded and poorly sorted; some shattered; slightly hard; -15% fine fine earth.

37 Reg Soil, Pleistocene — Southern Negev — Nahal Hiyyon

	depth,cm	
A_0		Desert pavement of flint gravel.
A_1		0- 2 Vesicular layer; slightly gravelly loam; very pale brown 10YR7/4 dry; light yellowish brown 10YR6/4 wet; gradual boundary.
A_3	2- 6	Slightly gravelly (10%) loam with many small (1mm) white mottles apparently of soft gypsum; massive; pink 7.5YR7/4 dry, strong brown 7.5YR5/6 wet; gradual boundary.
B_{2cs}	6- 21	Gravelly (20% gravel) loam to clay loam with numerous large gypsum concentrations of low bulk density; loose; reddish yellow 5YR6/6 dry, yellowish red 5YR4/6 wet; gradual boundary.
B_{3cs}	21- 36	Gravelly (70% gravel) loam with gypsum crystals and concentrations of various dimensions; loose; reddish yellow 7.5YR6/6 dry, strong brown 7.5YR5/6 wet; clear boundary.
B_3	36- 50	Similar to above layer, with more (50%) gravel and without a gypsum concentration; clear boundary.
C_{1cs}	50- 78	Loamy layer, mostly somewhat indurated by gypsum (60% of the layer); slightly hard; white dry, strong brown 7.5YR5/6 wet; clear boundary.
C_{1cs}	78- 94	Very gravelly and stony (60%) sandy loam, somewhat indurated by gypsum; massive; soft to slightly hard; reddish yellow 7.5YR6/6 dry, strong brown 7.5YR5/6 wet; gradual boundary.
C_{1cs}	94-126	Similar to above layer, with more stones and gravel (80%) and more indurated by gypsum; clear boundary.
C_{1ca}	126-150	Sandy loam indurated by gypsum and lime; massive; hard; white dry, pink 7.5YR7/4 wet; clear boundary.
B_b		Very gravelly (80%) sandy loam, somewhat indurated by gypsum; massive; hard; yellowish red 5YR4/8 dry and wet.

38 Reg Soil, Pleistocene — Southern Negev — Qetura

	depth,cm	
A_0		Desert pavement of dolomite gravel with some flint gravel.
A	0- 3	Vesicular layer of 1cm grading at depth to massive layer; 20% gravel and stones, loam to silt loam; pink 8YR7/4 dry, reddish yellow 7.5YR6/6 wet; clear boundary.
B_y	3- 8	Gravelly loam (20% gravel), with many small white gypsum or lime flecks (1-2mm); loose; pink 7.5YR7/4 dry, strong brown 7.5YR5/6 wet; wavy clear boundary.

B_{2cs}	6- 15	White gypsum with low bulk density, some gravel (10-20%); massive; soft; wavy abrupt boundary.
b_{2cs}	15- 22	Gravelly sandy loam (20% gravel), with many (10-20%)) soft small gypsum concentrations (1-2mm); loose; clear boundary; pink 7.5YR7/4 dry, reddish yellow 7.5YR6/6 wet.
B_{2cs}	22- 38	Sand loam with few gypsum crystals; loose; pink 7.5YR7/4 dry, reddish yellow 7.5YR6/6 wet; clear boundary.
C_{1cs}	38- 63	Very gravelly and stony (80%) sandy loam, with little gypsum, gypsum crystals cover many stones and sometimes bridge between them; massive to loose; pink 7.5YR7/4 dry, strong brown 7.5YR5/6 wet; gradual boundary.

39 Reg Soil, Pleistocene — **Southern Negev — Timna Valley**

	depth,cm	
A_0		Desert pavement, covers 100% of the surface; pebbles - average of 3-5cm in diameter.
A_V	0- 2	Vesicular layer; reddish yellow 7.5YR6/6 dry, strong brown 7.5YR5/8 wet; abrupt boundary.
B_1	2- 20	Silty, gravel free horizon; petrogypsic horizon; pink 7.5YR7/4 dry, strong brown 7.5YR5/8 wet.
B_2	20- 60	Shattered pebbles with rounded gypsum crystals; reddish yellow 5YR6/6 dry, yellowish red 5YR5/6 wet.
C_1	60- 90	Rounded pebbles; gypsum nodules; loose; light reddish brown 5YR6/4 dry, yellowish red 5YR5/8 wet.
C_2	90-110	Gravel, some shattered; very loose; some nodules; reddish yellow 7.5YR6/8 dry, strong brown 7.5YR5/8 wet.
		The profile contains 10-20% fine earth;

40 Reg Soil, Pleistocene — **Eastern Sinai — Wadi Khuweit**

	depth,cm	
A_0		Desert pavement covers 80-90% of the surface; pebbles, average of 2-3cm in diameter, cobbles 10-15cm, max. 30cm; the gravel is shattered and weathered.
A_1	0- 2	Silty; vesicular structure; small vesicles of 1-1.5mm in diameter; pink 7.5YR8/4 dry, reddish yellow 7.5YR6/6 wet; clear and wavy boundary.
B	2- 16	Fines with some small pebbles; reddish yellow 7.5YR7/8 dry, strong brown 7.5 YR5/8 wet; wavy and gradual boundary.
C	16- 70	Shattered gravel; poorly sorted; concentration of salt flecks decrease with depth; salt crystals inside the shattered stones.

The profile contains 30% fine earth.

41 Reg Soil, Pleistocene — **Central Sinai**

Horizon	depth, cm	
A_0		Desert pavement covers 100% of the surface.
A_v	0- 3	Vesicular layer of sandy loam; very pale brown 10YR7/3 dry, yellowish brown 10YR5/5 wet; abrupt boundary.
A_2	3- 10	Loamy sand with some pebbles; some salts; massive to laminar; very pale brown 10YR7/3 dry, light yellowish brown 10YR6/4 wet; abrupt boundary.
B_1	10- 19	Loamy sand with some pebbles; columnar structure; strong brown 7.5YR5/6 dry and wet; gradual boundary.
B_{2cs}	19- 35	Loamy sand with 30% pebbles; light brown 10YR6/4 dry, strong brown 7.5YR5/6 wet; wavy boundary.
$B_{2sa,cs}$	35- 47	Loamy sand with 30% pebbles; some gypsum crystals; light brown 7.5YR6/4 dry, strong brown 7.5YR5/6 wet; gradual boundary.
C_{1cs}	47-100	Petrogypsic horison highly cemented; very pale brown 10YR8/3 dry, light yellowish brown 10YR6/4 wet; gradual boundary.
C_{1cs}	100-110	Petrogypsic horison slightly cemented; gradual boundary.
C_{1cs}	110-120	Loam; some gypsum crystals which decrease with depth; very pale brown 10YR8/4 dry and wet; gradual boundary.

42 Reg Soil, Pleistocene — **Central Sinai**

Horizon	depth, cm	
A_V	0- 7	Vesicular layer; sandy loam; light yellowish brown 10YR6/4 dry, yellowish brown 10YR5/4 wet; clear wavy boundary.
B_{2sa}	7- 16	Clay loam with 30% pebbles; salt crystals and gypsum mottles; loose; yellowish red 5YR4/6 dry, yellowish red 5YR4/6 wet, gradual boundary.
B_{3sa}	16- 25	Loam to clay loam with 30% pebbles; loose; 6YR5/6 dry, 4YR5/6 wet.
BC_{sa}	25- 39	Loamy sand with 50% pebbles; loose; pink 7.5YR7/4 dry, reddish yellow 7.5YR 6/6 wet; gradual boundary.
C_{1sa}	39- 50	Sandy loam to loamy sand with 60% pebbles; very pale brown 10YR7/3 dry, brownish yellow 10YR6/5 wet; gradual boundary.
C_{1cs}	50- 80	Loamy sand with 70% pebbles; slightly cemented by gypsum; gradual boundary.

C_1	60- 95	Sand with 60% pebbles; loose; pink 7.5YR7/4 dry, reddish yellow 7.5YR6/6 wet; gradual boundary.
C_1	95-120	Loamy sand with 60% pebbles; cemented by gypsum; strong brown 7.5YR5/6 dry and wet.

43 Reg Soil, Pleistocene — Central Negev -- Makhtesh Ramon

	depth,cm	
A_0		Desert pavement covers the surface; pebbles averaging 3cm in diameter; some boulders of max. 80cm.
A_1	0- 5	Silty; gravel free horison; placky structure; cohesive; yellow 10YR7/6 dry, brownish yellow 10YR6/8 wet; indistinct boundary.
C_1	5- 25	Fines with some pebbles; salt flecks; yellow 10YR7/6 dry, brownish yellow 10YR6/8 wet.
C_2	25- 50	Fines with some pebbles; salt nodules; reddish yellow 7.5YR7/6 dry, 7.5YR7/6 wet.

44 Reg Soil, Tertiary — Northen Negev — Zin Valley

	depth,cm	
A_0		Desert pavement covers 100% of the surface; well sorted pebbles average 3cm in diameter; max. 20cm; well packed.
A_V	0- 2	Silty; vesicular structure, medium developed vesicles of 1-2mm in diameter; clear boundary.
B_1	2- 10	Fines, gravel free layer; indistinct boundary.
B_2	10- 15	Fines, gravel free layer; some friable gypsum flecks; indistinct boundary.
BC	15- 40	Shattered pebbles with fines; gypsum nodules.
B_{bcs}	40-150	Petrogypsic horison; highly cemented; with some pebbles.

45 Reg Soil (age?) — Central Negev — Makhtesh Ramon

	depth,cm	
A_0		Cover of pebbles 3-5cm in diameter.
A_1	0- 1	Fines without vesicles; loose; powdery; yellow 10YR8/8 moist, brownish yellow 10YR6/8 wet; indistinct boundary.
A_2	1- 15	Fines; powdery; some pebbles; brownish yellow 10YR6/8 wet; clear boundary.
C_{1cs}	15- 25	Shattered gravel with fines; reddish yellow 7.5YR7/8 dry, 7.5YR6/8 wet.
C_{2cs}	25- 50	Shattered gravel with fines; flecks of crystaline gypsum; reddish yellow.

B_{bcs}	60- 80	Nodules of gypsum; reddish yellow 7.5YR8/8 moist, strong brown 7.5YR5/8 wet.
		The profile contains 40–50% fine earth from 7cm to 80cm.
46 Reg Soil (age?)		**Southern Negev — Sde Etsyon**
	depth,cm	
A_0		Desert pavement covers 70% of the surface; gravel max. 20–30cm, average 10cm in diameter; 30% of the cover is fine earth.
A_V	0- 3	Vesicular layer; abrupt boundary.
B_1	3- 15	Gravel free layer; massive structure; loose; brownish hue.
C_1	15- 30	Pebbles (about 20%) 5cm in diameter; massive structure; brownish hue.
C_{cs}	30- 75	Fines with about 20% pebbles; laminar horizontal structure; some crystalline gypsum (3mm in diameter) down to 60cm.
47 Reg Soil (age?)		**Eastern Sinai — Wadi El Qsaib**
	depth,cm	
A_0		Medium sorted gravel (5–10cm) of limestone and flint cover the surface; angular.
A_V	0-0.2	Vesicular layer; vesicles of 0.5–1mm in diameter; yellow 10YR7/6 wet; wavy boundary.
B_{cs}	0.2- 5	Small pebbles; some salts; reddish yellow 7.5YR6/8 wet.
C_{1cs}	5- 25	Fines with shattered gravel; many salts within the layer; salts coat the gravel as well; reddish yellow 7.5YR7/8 dry, 7.5YR6/8 wet; wavy boundary.
C_{2cs}	25- 75	Shattered gravels with salts lying on top of sandstone; salt flecks and salt nodules in between the stones.
		The profile contains 50% fine earth.
		The compaction of the profile is loose.
48 Hammada Soil		**Central Negev — Mount Sagi**
	depth,cm	
A_0		Desert pavement covers 85% of the surface; limestone pebbles of 2–3cm in diameter; some cobles of 15cm in diameter.
A_1	0- 3	Silty; very weak vesicular structure; very loose; yellow 10YR8/6 dry, 10YR7/8 wet; abrupt boundary.
B_{cs}	3- 7	Silty; gravel free horizon; laminar structure; friable lime concretions; yellow 10YR7/8 moist, gradual boundary.

C_{1cs}	7- 30	Gravel with some fines; friable lime and gypsum spots in between the stones; yellow 10YR8/6 dry; abrupt boundary.
C_{2cs}	30- 40	Petrogypsic horison; salt and gypsum underneath the stones; white fines with gypsum crystals.

49 Hammada Soil — Central Negev — Mount Sagi

	depth,cm	
A_0		Rock fragments cover 80% of the surface; average of 2-3cm in diameter; some (-40%) rounded and angular cobbles; biological crust with fines in between the stones.
A_1	0- 10	Silty, gravel free; friable to loose; very pale brown 10YR8/4 dry.
C_1	10- 30	Silt with pebbles 10-15cm in diameter.
C_2	30- 60	Boulders with some fines.

50 Hammada Soil — Central Negev — Mount Lots

	depth,cm	
A_0		Rock fragments cover -60% of the surface; cobbles 10-15cm in diameter; biological crust in between the stones.
A_1	0- 10	Fines with small pebbles; friable to loose; flaky structure; some small vesicles under the biological crust; many roots; very pale brown 7/4 dry, yellowish brown 10YR5/8 wet; gradual boundary.
C	10- 30	Gravel with some fines; many roots corrode the stones.

51 Hammada Soil — Central Negev — Hameishar

	depth,cm	
A_0		Rock fragments cover the surface, average 2-3cm in diameter.
A_v	0- 1	Loamy silt; friable; very pale brown 10YR7/3 dry.
B	1- 10	Loamy silt with 30% pebbles; friable structure; reddish yellow 7.5YR6/6 dry.
BC	10- 28	Soil in pockets of the eroded rock; reddish yellow 7.5YR6/6 dry.
B_{cs}	28- 50	Discontinuous gypsic layer in rock cracks, and some fines.

52 Hammada Soil

Southern Negev — Mount Berekh

	depth,cm	
A_0		Rock fragments cover 100% of the surface, average 3–4cm in diameter.
A_v	0-0.5	Vesicular layer; weak.
AB	0.5- 5	Silty with some gravel.
C_{ss}	5- 40	Shattered gravel with fines; loose; reddish yellow 7.5YR6/8 dry, strong brown 7.5YR5/8 wet.

53 Lithosol

Judean Desert -- Mispe Hagagon

	depth,cm	
A_0		Desert pavement of chalk gravel, 50% of the surface.
A_v	0- 2	Very gravelly (30%), fine sandy loam; vesicular layer, massive; soft; very pale brown 10YR8/3 dry, yellowish brown 10YR5/6 wet; clear boundary.
B	2- 22	Very gravelly (30%) loam; pink 7.5YR7/4 dry, strong brown 7.5YR5/6 wet; abrupt boundary.
C_{1cs}	22- 44	Gypsum crust with some weathered chalk.
C_{2cs}	44+	Weathered chalk.

54 Lithosol

Northen Negev — Sde Boker

	depth,cm	
A	0- 35	Clay loam; loose; some roots; light yellowish brown 10YR6/4 dry, yellowish brown 10YR5/4 wet; gradual boundary.
C	35- 60	Similar to above layer, with less roots.

55 Lithosol

Northern Negev — Sde Boker

	depth,cm	
A	0- 10	Sandy clay loam; subangular blocky structure; loose; many roots; very pale brown 10YR7/4 dry, yelowish brown 10YR5/4 wet; abrupt boundary.
A_1	10- 30	Gravelly layer (80%) of average 20cm in diameter; some fines.
BC	30- 55	Clay; subangular blocky structure; loose; 40% gravel with max. 8cm in diameter; lime nodules up to 2cm in diameter; very pale brown 10YR7/4 dry and wet; gradual wavy boundary.
C_1	55- 70	Clay; massive structure; friable; gradual boundary.

C_{3ca}	70+	Clay; massive structure; very pale brown 10YR8/4 dry, 10YR7/4 wet.

56 Lithosol — Northen Negev — Sde Boker

	depth,cm	
A	0- 20	Clay loam; massive structure; friable ; many roots; very pale brown 10YR7/4 dry, yellowish brown 10YR5/4 wet; gradual boundary.
C_1	20- 35	Clay loam to sandy clay; flaky structure; friable; 80-90% cobbles 8-12cm in diameter; very pale brown 10YR7/4 dry, yellowish brown 10YR5/4 wet; gradual boundary.
C_2	35- 60	Sandy clay with eroded rock fragments; loose; very pale brown 10YR8/4 dry, very pale brown 10YR7/4 wet; wavy gradual boundary.

57 Serosem Soil — Jordan Valley

	depth,cm	
A_1	0- 10	Loam; lime crystals; hard; very pale brown 10YR7/3 dry, light yellowish brown 10YR7/3 wet; clear wavy boundary.
A_2	10- 25	Silt loam to silty clay loam; crumb structure to vesicular; hard; very pale brown 10YR7/3 dry, light yellowish brown 10YR6/4 wet; gradual boundary.
AC	25- 50	Silty clay loam; massive; gradual boundary.
C_{1cs}	50- 62	Similar to above layer; with white mottles and gypsum crystals; soft; gradual boundary.
C_{1cs}	62-101	Similar to above layer; massive; some white mottles and large gypsum crystals; gradual boundary.
C_{1cs}	101-124	Silty clay loam; many gypsum and lime crystals; massive; hard; white 5YR8/2 dry, light grey 5yr 7/2 wet; gradual boundary.
C_{1cs}	124-138	Similar to above layer; lighter color; bedded structure; gradual boundary.
C_{1cs}	138-157	Silty clay loam; gypsum and lime crystals; massive; hard; very pale brown 10YR8/3 dry, pale brown 10YR6/3 wet; gradual boundary.
C_{1cs}	157-174	Silt loasm; calcic; masive; hard; white 5Y8/1 dry, light grey 5Y7/2 wet; abrupt boundary.
IIC_2	174-219	Lisan marl; silty clay loam; hard; white 5Y8/2 dry, pale yellow 5Y7/3 wet; abrupt boundary.
IIC_3	219-290	Lisan marl, silt loam; hard; white 5Y8/1 dry, light grey 5YR7/2 wet.

58 Serosem Soil — **Judean Desert — Rugm En Naqa**

	depth,cm	
A_0		Cover of flint gravel and stones; 50-70% of the surface.
A	0- 22	Calcareous gravelly (20%) silt loam; faint, fine subanguylar blocky structure; loose to slightly hard; light yellowish brown 10YR6/4 dry, strong brown 7.5YR5/6 wet; clear boundary, with many stones.
B_{2ca}	22- 60	Slightly gravelly (5%) silty clay loam with many (30%) soft lime nodules; strong, fine subangular blocky structure; hard; brown 7.5YR5/4 dry and wet; wavy boundary.
B_{3cs}	60- 71	Slightly gravelly (5%) silty clay loam with some soft lime flecks and some mycelia of crystalline gypsum; massive slightly hard; brown 7.5YR5/4 dry and wet; wavy boundary.
BC_{cs}	71- 98	Silty clay loam with many mycelia of crystalline gypsum; massive, hard; very pale brown 10YR7/4 dry, light yellowish brown 10YR6/4 wet; clear boundary.
IIC_{cs}	98+	Massive silty loam disintegrating chalk with gypsum crystals; very hard, pinkish grey 7.5YR7/2 dry, pink 7.5YR8/4 wet; gradual boundary to the underlying soft rock.

59 Gravelly Regosol — **Southern Negev — Mount Amram**

	depth,cm	
A_0		Angular rock fragments; pebbles average 5cm in diameter; max. cobbles 10cm.
C_1	0- 40	Shattered pebbles grading at depth from large to small, max. 5cm in diameter; salts; brownish yellow 10YR6/6 dry, yellowish brown 10YR5/8 wet.
C_2	40- 60	Shattered pebbles with some salts; yellow 10YR7/6 dry, yellowish brown 10 YR5/6 wet.

60 Gravelly Regosol — **Southern Negev — Mount Amram**

	depth,cm	
		Angular gravel; average of 10cm in diameter, covers the surface.
	0- 5	Small pebbles without fines, average 0.5cm in diameter; well sorted; massive; well compacted; -10% fine earth; yellow 10YR7/6 dry, strong brown 7.5YR5/6 wet.
	12- 27	Small pebbles of average 1cm in diameter; well sorted; massive; some fines coating the stones.
	27- 42	Pebbel sand cobbles average 1cm in diameter; max. 15-20cm; 10% fine earth; medium sorting; massive; yellow 10YR7/6 dry, yellowish brown 10YR5/6 wet.

	42- 60	Pebbles of average 1.5cm in diameter; well compacted; some fines coating the stones.

The compacting of the profile is loose.

61 Gravelly Regosol — Southern Negev — Mount Amram

	depth,cm	
A_0		Rock fragments cover 100% of the surface.
A_v	0- 2	Vesicular layer, vesicles of 3-4mm in diameter; wavy boundary; some pebbles intruded from the above layer.
C_1	2- 30	Pebbles of average 4.5-5cm in diameter, max. 10cm; medium sorting; imbricate structure; massive; loose; -10% of fines coating the stones.
C_1	30- 50	Pebbles, average 2cm in diameter, max. 4cm; well sorted; massive; 40% fines fill the spaces between the stones; brownish yellow 10YR6/6 dry, yellowish brown 10YR5/8 wet.
C_1	50- 70	Pebbles, average 3cm in diameter; 20% fine earth; loose.
C_2	70- 95	Small pebbles; average 1cm in diameter, with granules; 10-15% of fine earth; salts are coating the stones; some of the pebbles are shattered; compact packing; light yellowish brown 10YR6/4 dry, dark yellowish brown 10YR4/6 wet; clear boundary.
C_3	95-135	Angular pebbles of average 2.5-3cm in diameter; most of the pebbles are shattered; salt crystals cover many stones; from depth of 110cm downward, many salt and gypsum crystals; light yellowish brown 10YR6/4 dry, brown to strong brown 7.5YR5/4-6 wet.

62 Gravelly Regosol — Eastern Sinai — Wadi Mukeibila

	depth,cm	
A_0	0- 10	Well developed desert pavement covers 95% of the surface; medium sorting.
C_1	10- 35	Unsorted gravel with many fines.
S	35-100	Fines with some unsorted grit and pebbles; loose.
		The profile contains 40-50% fine earth.

64 Dune Sand — Western Negev — Mount Qeren

Pit No.	
2	Climbing dume from west to east.
4	Active sand dune at a river bank, northen slope.
5	Stabilised sand dune at a river bank, upper crust (1–3cm)
8	Friable sand dune at a river bank (50cm)

65 Alluvial Sand — Western Negev — Be'eri

	depth,cm	
A	0- 48	Loamy sand; massive structure; hard; light yellowish brown 10YR6/4 dry, yelowish brown 10YR5/5 wet; gradual boundary.
B_{ca}	48-108	Sandy loam; hard carbonate nodules (-10%) 1cm in dimeter; hard; 9YR6/4 dry, dark yellowish brown 10YR4/6 wet; gradual boundary.
C_1	108-138	Sand; some hard carbonate nodules (-2%); hard ;light yellowish brown 10YR6/4 dry, yellowish brown 10YR5/6 wet; gradual boundary.
C_2	138-180+	Similar to above layer, with less carbonate nodules; very pale brown 10YR 7/4 dry.

66 Alluvial Sand; — Western Negev — Kissofim

	depth,cm	
A	0- 28	Sand to sandy loam; friable; yellowish brown 10YR5/4 dry, dark yellowish brown 10YR 4/4 wet.
B_{ca}	28- 73	Sandy loam; some hard carbonate *concretions* (2–3%) 0.5–1cm in diameter; massive to crumby structure; light yellowish brown 10YR6/4 dry, yellowish brown 10YR5/4 wet; gradual boundary.
B_{ca}	73-103	Similar to above layer; Yellowish brown 10YR5/6 wet; gradual boundary.
C_{1ca}	103-143	Sand; hard carbonate nodules (10%) 0.5–1cm in diameter; masive to loose; very pale brown to light yellowish brown 10 YR6.5/4 dry, yellowish brown 10YR5/6 wet; gradual boundary.
C_{1ca}	143-210	Similar to above sand, coarser and loose.
C_2	210-300	Similar to above sand with very little amount of small carbonate concretions.

67 Alluvial Sand — Western Negev — Kissofim

	depth,cm	
A	0- 31	Sand to sandy loam; friable; light yellowish brown 10YR6/4 dry, yellowish brown 10YR5/4 wet; gradual boundary.
B_{ca}	31- 60	Sandy loam; some hard carbonate nodules (-5%); massive structure; light yellowish brown 10YR6/4 dry, yellowish brown 10 YR5/6 wet; gradual boundary.
C_1	60-101	Sand; some hard carbonate nodules (-2%); massive to loose; light yellowish brown 10YR6/4 dry, yellowish brown 10YR5/6 wet; gradual boundary.
C_2	101-175	Similar to above layer; light yellowish brown to yellowish brown 10YR5.5/4 dry and wet.

68 Sandy Regosol — Western Negev — Yamit

	depth,cm	
A	0- 40	Massive sand; soft; very pale brown 10YR7/4 dry, light yellowish brown 10YR6/4 moist; gradual boundary.
C_{1ca}	40-100	Massive sand, somewhat finer with few hard lime nodules (5mm); gradual boundary.
C_{1ca}	100-140	Masive sand with more hard lime nodules (2-3%) which decrease in number with depth; gradual boundary.
C_2	140-250	Coarser sand without lime nodules, from 190cm downward the sand becomes finer again.

69 Brown Alluvial Soil — Jordan Valley — Fatsael

	depth,cm	
A	0- 17	Gravelly (-50%) silt loam; subangular blocky structure; calcareous; hard; very pale brown 10YR7/3 dry, yellowish brown 10YR5/4 wet; wavy boundary.
B_{2ca}	17- 44	Very gravelly (-70%) silt loam; many big lime mottles; petrocalcic horison in developement; subangular blocky structure; hard; light brown 7.5YR6/4 dry, brown 7.5YR5/4 wet; wavy boundary.
B_{3ca}	44- 70	Similar to above layer, coarser sandy loam; lots of lime mottles; wavy boundary.
B_{3ca}	70-112	Gravelly (-60%) sandy loam; lime mottles; loose; light brown 7.5YR6/4 dry, brown 7.5YR5/4 wet; wavy boundary.
C	112-160	Similar to above layer; about 70% gravel; no lime mottles.

70 Brown Alluvial Soil **Jordan Valley**

depth,cm

0- 8	Gravelly (-50%) loam; crumbly to platy structure; calcareous; hard; very pale brown 10YR7/3 dry, light yellowish brown 10YR6/4 wet; wavy boundary.
8- 24	Loam with gravel (-20%); calcareous; masive structure; hard; very pale brown 10YR7/3 dry, light yellowish brown 10YR6/4 wet; wavy boundary.
24- 62	Loamy sand with gravel (-70%) massive structure; calcareous; loose; very pale brown 10YR7/3 dry, light yellowish brown 10YR6/4 wet; abrupt wavy boundary.
62-115	Sandy loam with gravel (-70%); massive structure; calcareous; lose; verypale brown 10YR7/3 dry, light yellwoeih brown 10YR6/4 wet; wavy boundary.
115-122	Silt loam with gravel (-70%); massive to platy structure; calcareous; hard; very pale brown 10YR8/3 dry, 10YR7/3 wet; wavy boundary.
122-144	Loam with some gravel (-10%); carbonate concretions and mycelia; massive structure; crumby; very pale brown 10YR 7/3 dry, light yellowish brown 10YR6/4 wet; wavy boundary.
144-200	Loam with gravel(-70%); massive structure; calcareous; loose; very pale brown 10YR8/3 dry, 10YR7/4 wet.

71 Brown Alluvial Soil **Jordan Valley**

depth,cm

0- 10	Loam with some gravel (-5%); crumby; white 10YR8/2 dry, very pale brown 10YR7/3 wet; wavy boundary.
10- 30	Silty clay loam with some gravel (-5%); massive structure; calcareous; hard; very pale brown 10YR7/3 dry, light yellowish brown 10YR6/4 wet; gradual boundary.
30- 63	Loam with some gravel (-10%); massive structure; calcareous; hard; very pale brown 10YR7/3 dry, light yellowish brown 10YR6/4 wet; wavy boundary.
63- 76	Sandy loam with gravel (-70%); loose; white 10YR8/2 dry, light gray 10YR7/2 wet; wavy boundary.
76- 90	Gravelly (-90%) with some sandy loam; salty and calcareous; loose; light gray 10YR7/2 dry, pale brown 10YR6/3 wet; abrupt boundary.
90- 108	Lisan marl — silty clay loam with some gravel (-5%); massive to platy structure; calcareous; hard; white 10YR8/2 dry, light gray 10YR7/1 wet; gradual boundary.

	108-170	Lisan marl — silty clay loam; platy structure; hard; very pale brown 10YR7/3 dry and wet.

72 Brown Alluvial Soil — Jordan Valley

	depth,cm	
A	0- 19	Loam with some gravel (-10%); salty and calcareous; loose; very pale brown 10YR7/3 dry, yellowish brown 10YR5/4 wet; wavy bounday.
C_1	19- 40	Loam with gravel (15-[illegible]%); massive to loose; salty and calcareous; very pale brown 10YR7/3 dry, yellowish brown 10YR5/4 wet, clear wavy boundary.
C_1	40- 75	Loamy sand with gravel (-25%); salty and calcarous; loose; very pale brown 10YR7/3 dry, light yellowish brown 10YR6/4 wet; wavy boundary.
C_1	75-107	Loamy sand with gravel (-50%); massive to loose; salty and calcareous; very pale brown 10YR7/3 dry, light yellowish brown 10YR6/4 wet; wavy boundary.
C_1	107- 140	Sandy loam with gravel (-40%); loose; salty and alcareous; very pale brown 10 YR7/3 dry, light yellowish brown 10YR6/4 wet; abrupt boundary.
C_{ca}	140-153	Petrocalcic horison, highly cemented.
II_{C2}	153-180	Lisan mare beds; silty clay loam.

73 Grumusol — Western Negev

	depth,cm	
A	0- 16	Silty clay loam; hard; brown 7.5YR5/4 dry, brown to dark brown 7.5YR4/4 wet; wavy boundary.
B_1	16- 30	Similar to above layer; coarse columnar structure; hard; gradual boundary.
B_2	30- 67	Clay, coarse columnar structure; hard; brown 7.5YR5/4 dry, brown to dark brown 7.5YR4/4 wet; gradual boundary.
B_2	67-120	Similar to above layer; blocky structure with slickensides; some carbonate nodules (1-2%) 4-5cm in diameter.
B_{2ca}	120-160	Clay, carbonate concretions (5%); black mycelia of manganese on aggregates; gradual boundary.
B_{2ca}	160-200	Similar to above layer; with slickensides; reddish brown 5YR4/4 dry and wet.

74 Grumusol — Eastern Samarian Mountains — Ma'ale Efraim

	depth,cm	
A_0		Some limestone gravel is found on the soil surface.

B_1	10- 40	Calcareous clay; wide cracks, 23-30cm, fine platy structure; very hard; reddish brown 5YR4/4 dry and wet; gradual boundary.
B_2	40- 75	Similar clay with very coarse columnar structure and secondary platy structure; cracks.
B_3	75-125	Similar clay with polyhedric bicuneate structure; indistinct boundary.
B_3	125- 50	Similar clay with few hard lime concretions; dark reddish brown 5YR3/4 dry and wet.

75 Grumusol — Jordan Valley

	depth,cm	
A_1	0- 4	Silty clay loam; calcareous; aggregate to platy structure; hard; yellowish brown 10YR5/4 dry, brown to dark brown 10YR4/3 wet; abrupt boundary.
A_3	4- 21	Silty clay loam to silty clay; calcareous; columnar, massive structure; hard; light yellowish brown 10YR6/4 dry, brown to dark brown 10YR4/3 wet; gradual boundary.
B_2	21- 45	Silty clay; coarse blocky structure; calcareous; aggregates coated with clay; very hard; brown to dark brown 7.5YR4/4 dry and wet; gradual boundary.
B_2	45- 80	Silty clay; calcareous; blocky structure; aggregates coated with clay; diagonal slickensides ; hard; brown to dark brown 7.5YR4/4 dry and wet; gradual boundary.
B_3	80-120	Similar to above layer; brown 7.5YR5/4 dry, brown to dark brown 7.5YR4/4 wet; gradual; boundary.

G.8.1 SELECTED SOILS AND DEPOSITS — DATA

No.	Soil Type; Type of Surficial Deposit	Physiographic Unit/Landform	Pit Site	Local Parent Material	Climate (P,mm/yr)	Region, Location	Coordinates (Israel Grid)	Soil Horizon	Depth, cm	E. Co
1.	Loessial Soil	Loessial Plain	-	Loess	Semi-arid (350)	Northwestern Negev, Netivot	1109 0938	A	0 - 30	
								AB	30 - 50	
								B_{bca}	50 - 85	
								B_{bca}	85 -100	
2.	Loessial Soil	Alluvial Terrace	-	Loess	Semi-arid (270)	Western Negev	0936 0840	A	0 - 40	
								B	40 - 77	
								B	77 -112	
								B_b	112 -158	
								B_b	158 -180	
								B_b	130 -210	
3.	Loessial Soil	Loessial Plain	-	Loess	Semi-arid (250)	Western Negev	0906 0837	A_1	0 - 27	
								A_3	27 - 70	
								C_1	70 - 97	
								C_1	97 -144	
								C_1	144 -160	
								C_2	160 -200	
4.	Brown Loessial Soil	Alluvial Terrace	-	Loess	Semi-arid (300-350)	Western Negev	1024 0883	A	0 - 26	
								A	26 - 52	
								B_{ca}	52 - 96	
								C_1	96 -120	
								C_2	120 -160	
5.	Brown Loessial Soil	Undulating Hill	Plateau-Divide	Loess	Semi-arid (300-350)	Western Negev	1032 0882	A	0 - 42	
								B_{ca}	42 - 78	
								C_1	78 -101	
								B_b	101 -120	
								B_b	120 -166	
6.	Brown Loessial Soil	Hillslope	-	Loess	Semi-arid (300-350)	Western Negev	1028 0880	A	0 - 44	
								B_1	44 - 67	
								B_{2ca}	67 - 88	
								BC	88 -116	
								C	116 -180	
7.	Light Brown Loessial Soil	Hillslope	-	Loess	Semi-arid (300)	Western Negev	1083 0877	A	0 - 28	
								B_{2ca}	28 - 45	
								B_{2ca}	45 - 65	
								BC	65 - 90	
								C_1	90 -130	
								C_2	130 -200	
8.	Light Brown Loessial Soil	Hillslope	-	Loess	Semi-arid (275)	Western Negev	0953 0870	A	0 - 30	
								B_{2ca}	30 - 80	
								B_{3ca}	80 -113	
								C_1	113 -160	
								C_2	160 -210	

	Coordinates (Israel Grid)	Soil Horiz...	Depth, cm	Electrical Conductivity, mmho/cm	Gypsum, %	Sand, %	Silt, %	Clay, %	Color, dry	Color, wet
stern Netivot	1109 0938	A	0 - 30	0.6	-	9.2	53.4	37.2	10YR6/4	9YR4/4
		AB	30 - 60	0.7	-	11.4	62.4	26.0	10YR6/4	10YR5/4
		B_{bca}	60 - 85	1.0	-	7.7	48.2	44.1	7.5YR4.5/4	7.5YR4/4
		B_{bca}	85 -100	1.8	-	9.9	46.0	44.1	7.5YR5/4	7.5YR4/4
Negev	0936 0840	A	0 - 40	0.4	-	53.6	29.6	16.8	10YR6/4	10YR4/4
		B	40 - 77	0.4	-	56.4	29.9	16.7	10YR6/4	10YR5/4
		B	77 -112	0.6	-	55.8	26.3	17.9	-	-
		B_b	112 -158	1.7	-	52.5	26.1	21.4	10YR5/4	10YR4/4
		B_b	158 -180	3.3	-	44.2	29.5	26.3	10YR5/4	10YR4/4
		B_b	180 -210	3.4	-	40.0	33.2	21.8	10YR6/4	10YR4/4
Negev	0906 0837	A_1	0 - 27	0.7	-	79.[illegible]		9.0	10YR5/4	10YR4/4
		A_3	27 - 70	0.4	-	83.6	[illegible]	8.0	10YR6/4	10YR5/5
		C_1	70 - 97	0.4	-	83.0	[illegible].9	7.1	-	10YR5/5
		C_1	97 -144	0.3	-	75.6	[illegible]6.1	8.3	-	-
		C_1	144 -160	0.7	-	60.2	26.2	13.6	-	-
		C_2	160 -200	0.6	-	72.1	18.9	9.0	-	-
Negev	1024 0883	A	0 - 26	0.6	-	35.2	44.1	20.7	10YR5.5/4	10YR4/4
		A	26 - 52	1.5	-	29.6	48.5	21.9	-	-
		B_{ca}	52 - 96	0.9	-	27.9	46.4	25.7	10YR6/4	10YR5/4
		C_1	96 -120	1.4	-	39.0	42.3	18.7	-	-
		C_2	120 -150	1.7	-	40.8	41.0	18.2	-	-
n Negev	1032 0882	A	0 - 42	0.6	-	45.7	37.8	16.5	10YR6/3	10YR5/4
		B_{ca}	42 - 78	0.6	-	36.1	45.6	18.3	10YR6/4	10YR5/4
		C_1	78 -101	0.6		36.5	45.3	18.2	-	-
		B_b	101 -120	0.8	-	28.8	50.5	20.7	9YR5/6	10YR4/4
		B_b	120 -166	0.8	-	27.7	50.0	22.3	9YR5/6	10YR4/4
n Negev	1028 0880	A	0 - 44	0.6	-	34.2	37.6	28.2	10YR5/4	10YR4/4
		B_1	44 - 67	0.5	-	32.0	38.2	29.8	-	-
		B_{2ca}	67 - 88	0.8	-	34.3	36.1	29.6	10YR5/4	10YR4/4
		BC	88 -116	1.0	-	38.6	35.7	25.7	10YR6/4	10YR4.5/4
		C	116 -180	1.2	-	39.4	40.9	19.7	-	-
n Negev	1083 0877	A	0 - 28	0.5	-	-	17.9	12.3	10YR6/4	10YR4/4
		B_{2ca}	28 - 45	0.4	-	-	-	15.2	7.5YR7/4	7.5YR5/6
		B_{2ca}	45 - 65	0.4	-	-	-	13.7	-	-
		BC	65 - 90	0.4	-	-	-	10.9	7.5YR6/4	7.5YR5/6
		C_1	90 -130	0.4	-	-	-	7.4	7.5YR6/4	7.5YR5/6
		C_2	130 -200	0.5	-	-	-	4.9	7.5YR7/4	7.5YR5/6
n Negev	0953 0870	A	0 - 30	1.3	-	69.4	20.7	9.9	10YR7/3	10YR5/5
		B_{2ca}	30 - 80	0.4	-	72.4	19.5	8.1	10YR6/4	10YR5/6
		B_{3ca}	80 -113	0.4	-	79.7	13.9	6.4	-	-
		C_1	113 -160	0.4	-	87.4	9.1	3.5	10YR7/4	10YR5/6
		C_2	160 -210	0.3	-	96.5	2.8	0.8	10YR7/4	10YR5/6

No.	Soil Type; Type of Surficial Deposit	Physiographic Unit/Landform	Pit Site	Local Parent Material	Climate (P,mm/yr)	Region, Location	Coordinates (Israel Grid)	Soil Horizon	Depth, cm	Elect. Condu. mmh
9.	Light Brown Loessial Soil	Hillslope	Lower Hillslope	Chalk	Arid (95)	Northern Negev, Sde Boker	1270 0310	A	0 - 8	0.
								B_1	8 - 20	0.
								B_{2ca}	20 - 40	0.
								C_{ca}	40 - 65	1.
10.	Loessial Serozem Soil	Undulating Hill	Plateau-Hillslope Crest	Loess	Arid to Moderately Arid (150)	Western Negev, Be'er Sheva	1301 0700	A	0 - 12	4.
								B_{1ca}	12 - 33	13.
								B_{2sa}	33 - 61	14.
								B_{2sa}	61 - 91	21.
								$B_{b2ca,sa}$	91 -141	19.
								$B_{b2ca,sa}$	141 -191	16.
11.	Loessial Serozem Soil	Hillslope	Lower Hillslope	Chalk	Arid (95)	Northern Negev, Sde Boker	1270 0310	A	0 - 17	0.
								B_1	17 - 40	1.
								B_2	40 - 60	2.
								B_{2ca}	60 - 78	7.
								$B_{2cs,ca}$	78 -100	9.
12.	Loessial Serozem Soil	Hillslope	Lower Hillslope	Colluvium	Arid (95)	Northern Negev, Sde Boker	1270 0310	A	0 - 12	0.
								B_1	12 - 25	6.
								B_2	25 - 45	13.
								$B_{2cs,ca}$	45 - 65	20.
								$B_{2cs,ca}$	65 - 85	20.
								$B_{2cs,ca}$	85 -110	25.
								$B_{2cs,ca}$	110 -130	25.
13.	Loessial Serozem Soil	Plateau	Plateau-Saddle	Loess	Arid (90)	Northern Negev, Sde Boker	1310 0294	A_1	0 - 10	1.
								A_3	10 - 22	9.
								B_{1sa}	22 - 35	41.
								B_{2ca}	35 - 70	33.
								B_3	70 - 82	33.
								C_1	82 -105	28.
								C_1	105 -132	30.
								B_b	132 -165	27.
14.	Loessial Serozem Soil	Alluvial Terrace	-	Loess	Moderately Arid (230)	Judean Desert, Rujum Er. Naga	1772 1044	A	0 - 15	2.
								B_{1ca}	15 - 40	14.
								B_{2ca}	40 - 68	20.
								B_2	68 -107	18.
								B_{3cs}	107 -150	18.
								B_{bcs}	150 -180	16.
15.	Loess	Archaeological Site	Inside Ruin Fill	Loess	Extremely Arid (60)	Central Negev, Makhtesh Ramon	1440 0016		0 - 10	12.
									10 - 30	15.
									30 - 55	7.
									55 - 60	20.
									60 - 75	13.
									75 - 85	24.

	Coordinates (Israel Grid)	Soil Horizon	Depth, cm	Electrical Conductivity, mmho/cm	Gypsum, %	Sand, %	Silt, %	Clay, %	Color, dry	Color, wet
Negev, r	1270 0310	A	0 - 8	0.5	-	29.4	39.6	31.0	10YR7/4	10YR6/4
		B_1	8 - 20	0.4	-	21.5	36.5	42.0	10YR7/4	10YR6/4
		B_{2ca}	20 - 40	0.4	-	19.6	33.2	47.2	10YR7/4	10YR6/4
		C_{ca}	40 - 65	1.4	-	12.7	29.0	58.3	10YR7/4	10YR7/4
Negev, eva	1301 0700	A	0 - 12	4.3	-	35.2	46.8	18.0	10YR7/3	10YR6/4
		B_{1ca}	12 - 33	13.9	-	24.8	53.4	21.7	10YR6/4	10YR5/6
		B_{2sa}	33 - 61	14.5	-	24.4	58.8	16.8	10YR6/4	10YR5/4
		B_{2sa}	61 - 91	21.0	-	30.0	51.2	18.8	-	-
		$B_{b2ca,sa}$	91 -141	19.1	-	22.4	54.8	22.8	10YR5/4	10YR4/4
		$B_{b2ca,sa}$	141 -191	18.4	-	24.4	52.6	23.0	-	-
Negev, r	1270 0310	A	0 - 17	0.4	-	31.4	37.9	30.7	10YR7/4	10YR6/4
		B_1	17 - 40	1.0	-	23.5	42.6	33.9	10YR7/4	10YR7/4
		B_2	40 - 60	2.2	-	18.9	44.2	36.9	10YR7/4	10YR7/4
		B_{2ca}	60 - 78	7.3	2.6	18.9	44.2	36.9	-	-
		$B_{2cs,ca}$	78 -100	9.6	4.0	19.4	46.6	34.0	10YR7/4	10YR7/4
Negev, r	1270 0310	A	0 - 12	0.7	-	33.8	33.6	32.6	10YR7/4	10YR6/4
		B_1	12 - 25	5.7	-	33.2	32.3	34.5	10YR7/4	10YR6/4
		B_2	25 - 45	13.4	2.4	29.0	34.6	36.4	10YR6/4	10YR5/4
		$B_{2cs,ca}$	45 - 65	20.0	5.8	33.1	32.6	34.3	10YR7/4	10YR6/4
		$B_{2cs,ca}$	65 - 85	20.1	3.7	30.9	33.7	35.4	10YR7/4	10YR6/4
		$B_{2cs,ca}$	85 -110	25.9	2.5	34.3	28.9	36.8	10YR7/4	10YR6/4
		$B_{2cs,ca}$	110 -130	25.0	4.3	29.3	28.9	41.8	-	-
Negev, r	1310 0294	A_1	0 - 10	1.4	-	41.9	36.3	21.8	10YR7/3	10YR7/3
		A_3	10 - 22	9.6	0.5	33.8	41.0	25.2	10YR7/3	10YR7/3
		B_{1sa}	22 - 35	41.5	3.5	28.0	46.8	25.2	-	-
		B_{2ca}	35 - 70	33.2	1.2	23.6	43.4	33.0	7.5YR4.5/4	7.5YR4/4
		B_3	70 - 82	33.2	1.0	25.5	39.1	35.4	7.5YR5/6	7.5YR5/6
		C_1	82 -105	28.8	0.9	25.7	40.7	33.6	10YR6/4	10YR5/4
		C_1	105 -132	30.2	2.0	25.5	41.6	32.9	10YR6/4	10YR5/4
		B_b	132 -165	27.4	6.2	29.9	40.9	29.6	5YR5/6	5YR5/6
Desert, n Naga	1772 1044	A	0 - 15	2.0	-	28.8	52.9	18.3	10YR6.5/4	10YR5/6
		B_{1ca}	15 - 40	14.0	-	35.0	40.6	24.4	10YR6/4	10YR5/4
		B_{2ca}	40 - 68	20.5	-	36.8	37.2	26.0	7.5YR5/4	7.5YR4.5/4
		B_2	68 -107	18.8	-	36.5	39.5	24.0	7.5YR6/4	7.5YR5/4
		B_{3cs}	107 -150	18.0	2.0	28.7	44.0	27.3	7.5YR7/4	7.5YR7/4
		B_{bcs}	150 -180	18.8	-	23.7	41.5	34.8	7.5YR5/4	7.5YR5/4
Negev, h Ramon	1440 0016		0 - 10	12.0	4.1	44.7	49.6	5.7	10YR6/4-6	10YR5/6
			10 - 30	15.1	1.1	53.2	44.7	2.1	10YR5/6	10YR6/6
			30 - 55	7.2	6.2	56.6	38.0	5.4	10YR6/6	10YR4/6
			55 - 60	20.7	5.6	33.0	62.1	4.9	10YR6/6	10YR5/8
			60 - 75	13.5	16.5	42.6	55.6	1.8	2.5YR6/4	2.5YR6/8
			75 - 85	24.6	9.8	44.6	45.2	10.2	10YR7/4	10YR5/8

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No.	Soil Type; Type of Surficial Deposit	Physiographic Unit/Landform	Pit Site	Local Parent Material	Climate (P,mm/yr)	Region, Location	Coordinates (Israel Grid)	Soil Horizon	Depth, cm
16.	Loess	Archaeological Site	Inside Ruin Fill	Loess	Extremely Arid (40)	Southern Negev, Uvda Valley	1464 9286		0 - 5
									15 - 25
17.	Takyr Soil	Playa	Playa-Center	Fine Alluvium	Extremely Arid (40)	Southern Negev, Saharut Valley	1496 9257	A_1	0 - 30
								C_1	30 - 40
								C_2	40 - 70
18.	Takyr Soil	Playa	Playa-Margin/Center	Fine Alluvium	Extremely Arid (35)	Southern Negev, Qa En Naqb	1350 8920	A_1	0 - 12
								$C_{cs,sa}$	12 - 50
								$C_{cs,sa}$	50 - 80+
19.	Takyr Soil	Playa	Playa-Center	Fine Alluvium	Extremely Arid (35)	Southern Negev, Qa En Naqb	1350 8915	A_1	0 - 5
								A_3	5 - 10
								$B_{2cs,sa}$	10 - 20
								B_3	20 - 26
								C	26 - 40
								C	40 - 60
20.	Takyr Soil	Playa	Playa-Margin/Center	Granit, Igneous, Metamorphic, Limestone, Sandstone	Extremely Arid (25)	Eastern Sinai, Wadi Mukeibila	1298 8679	A_1	0 - 4
								C_1	4 - 14
								C_2	14 - 50
21.	Solonchak Soil	Plateau	Plateau-Saddle	-	Semi-arid (250)	Eastern Samarian Mountains, Ma'ale Efraim	1895 1645	A_1	0 - 13
								A_3	13 - 30
								B_2	30 - 60
								B_2	60 -100
								B_{2ca}	100 -120
22.	Solonchak Soil	Playa	-	Fine Alluvium	Extremely Arid (50)	Dead Sea, Ein Tamar	1854 0435		0 - 2
									2 - 14
									14 - 30
									30 - 50
									50 - 74
									74 -110
									110 -130
									130 -160
									160 -180
									180 -210
23.	Solonchak Soil	Playa	Playa-Margin/Center	Fine Alluvium	Extremely Arid (30)	Southern Arava, Avrona Playa	1510 8965		0 - 2
									2 - 10
									2 - 15
									15 - 26
									15 - 26
									42 - 36
									42 - 75

n	Coordinates (Israel Grid)	Soil Horizon	Depth, cm	Electrical Conductivity, mmho/cm	Gypsum, %	Sand, %	Silt, %	Clay, %	Color, dry	Color, wet
n Negev,	1464 9286		0 - 5	0.3	0	75.0	19.0	6.0	10YR7/8	10YR6/8
lley			15 - 25	0.8	0	72.0	23.3	4.6	10YR7/8	10YR5/8
n Negev,	1496 9257	A_1	0 - 30	0.8	0	37.8	47.9	14.2	10YR7/6	10YR6/8
Valley		C_1	30 - 40	3.0	1.6	24.7	50.3	24.9	7.5YR7/8	7.5YR6/6
		C_2	40 - 70	1.3	0	27.0	53.8	19.2	10YR7/6	10YR6/8
n Negev,	1350 8920	A_1	0 - 12	6.1	1.0	0	51.3	48.7	10YR6/8	7.5YR6-5/8
aqb		$C_{cs,sa}$	12 - 50	27.2	8.7	0	54.2	45.8	10YR6/8	7.5YR6-5/8
		$C_{cs,sa}$	50 - 80+	29.3	8.2	14.2	49.9	35.9	10YR6/8	7.5YR6-5/6
n Negev,	1350 8915	A_1	0 - 5	5.5	-	10.8	28.0	61.2	7.5YR7/4	7.5YR4.5/6
Naqb		A_3	5 - 10	13.2	-	9.1	28.5	63.4	-	-
		$B_{2cs,sa}$	10 - 20	40.0	9.1	14.3	21.6	64.1	7.5YR6/4	7.5YR4/8
		B_3	20 - 26	49.2	4.7	12.7	26.7	60.6	-	-
		C	26 - 40	41.5	6.8	10.9	50.6	38.5	-	-
		C	40 - 80	40.8	8.3	6.5	35.6	58.0	-	-
n Sinai,	1298 8679	A_1	0 - 4	0.5	0	1.6	74.0	24.5	-	-
ukeibila		C_1	4 - 14	0.3	0	26.6	62.0	11.0	-	-
		C_2	14 - 50	1.9	0	35.1	47.1	17.8	-	-
n Samarian	1895 1846	A_1	0 - 13	0.6	-	13.2	41.9	44.9	7.5YR6/4	7.5YR4/4
ins,		A_3	13 - 30	0.4	-	12.6	40.6	46.8	7.5YR5/4	7.5YR4/4
Efraim		B_2	30 - 60	4.0	-	10.4	41.5	48.1	7.5YR5/4	7.5YR4/4
		B_2	60 -100	5.4	-	10.0	41.2	48.8	6YR4/4	6YR4/4
		B_{2ca}	100 -120	4.8	-	9.7	41.8	48.5	5YR4/4	5YR4/4
Sea,	1854 0435		0 - 2	195.8	29.8	18.1	54.7	27.2	10YR7/2	10YR6/3
mar			2 - 14	132.1	22.5	31.0	49.0	20.0	-	10YR5/4
			14 - 30	87.0	11.9	2.1	60.4	37.5	5Y7/3	2.5Y6/2
			30 - 50	41.5	4.2	1.5	59.0	39.5	2.5Y8/2	2.5Y6/3
			50 - 74	34.2	17.8	1.5	48.5	50.0	2.5Y8/2	2.5Y6/8
			74 -110	32.8	4.0	3.7	56.0	40.3	2.5Y8/2	2.5Y6.5/2
			110 -130	39.6	3.7	1.0	54.0	45.0	2.5Y7/2	2.5Y7/2
			130 -160	54.4	1.8	40.5	44.8	14.7	-	-
			160 -180	43.5	4.7	2.1	59.3	38.6	-	-
			180 -210	48.2	2.4	9.3	59.6	31.1	-	-
ern Arava,	1510 8955		0 - 2	108.0	10.7	68.8	25.8	4.4		7.5YR5/6
Playa			2 - 10	53.7	3.6	76.1	16.1	7.8	7.5YR7/6	7.5YR5/6-8
			2 - 16	95.8	8.9	56.7	27.3	16.0	7.5YR7/6	7.5YR5/6
			15 - 25	156.8	16.2	87.6	---12.4----		7.5YR7/6	7.5YR5/4
			15 - 25	94.1	4.5	72.4	15.6	11.8	7.5YR7/6	7.5YR5/6
			42 - 35	57.6	5.4	48.3	---51.7----		-	7.5YR5/6
			42 - 75	21.8	6.1	80.1	14.9	5 0	-	7.5YR5/8

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No.	Soil Type; Type of Surficial Deposit	Physiographic Unit/Landform	Pit Site	Local Parent Material	Climate (P,mm/yr)	Region, Location	Coordinates (Israel Grid)	Soil Horizon	Depth, cm	El. Co.
24.	Solonchak Soil	Playa	Playa-Center	Fine Alluvium	Extremely Arid (20)	Eastern Sinai, Bir Sweir	1243 8556	A $C_{1sa,cs}$ $C_{2cs,sa}$	0 - 2 2 - 30 30 - 55	[illegible] [illegible] 1[illegible]
25.	Alluvium	Active Flood-plain	Channel	Limestone, Dolomite, Flint	Extremely Arid (60)	Dead Sea, Nahal Ze'elim	1845 0845		0 - 2 2 - 17 17 - 25	
26.	Alluvium	Active Flood-plain	-	Fine Alluvium	Extremely Arid (40)	Southern Negev, Uvda Valley	1478 9350		0 - 5 5 - 15 15 - 20 20 - 25 25 - 33 33 - 40 40 - 50 50 - 55	
27.	Alluvium	Active Flood-plain	-	Granite	Extremely Arid (20)	Eastern Sinai, Wadi Mandara	1040 8100		0 - 5 5 - 10 10 - 50	
28.	Alluvium (Saline)	Active Flood-plain	Channel	Limestone	Extremely Arid (30)	Central Sinai, Bir Thmada	0000 9550	A AC C_1 C_1 C_1	0 - 10 10 - 24 24 - 40 40 - 56 56 -110	1 3 1 1 1
29.	Reg Soil, Holocene	Alluvial Fan Terrace	Gravel Bar	Limestone, Dolomite, Flint	Extremely Arid (60)	Dead Sea, Nahal Ze'elim	1845 0855	A_v B C	0 - 0.5 0.5- 4.5 4.5- 35.5	 1
30.	Reg Soil, Holocene	Alluvial Terrace	-	Limestone, Flint	Extremely Arid (40)	Southern Negev, Wadi Paran	1464 9709	B B_{cs} C_1	0.3- 10 10 - 17 17 - 40	
31.	Reg Soil, Holocene	Alluvial Terrace	-	Limestone, Dolomite, Sandstone	Extremely Arid (30)	Southern Negev, Timna Valley	1468 9114	A_v A_1 B C_2	0 - 2 2 - 3.5 3.5- 6 9 - 14	 1
32.	Reg Soil, Holocene	Alluvial Fan Terrace	-	Granite, Igneous, Metamorphic, Limestone, Sandstone	Extremely Arid (25)	Eastern Sinai, Wadi Mukeibila	1295 8670	A_1 A_2 B_1 B_{2cs} B_{2cs} C	0 - 1 1 - 2 2 - 3.5 3.5- 12 3.5- 12 12 - 46	

	Coordinates (Israel Grid)	Soil Horizon	Depth, cm	Electrical Conductivity, mmho/cm	Gypsum, %	Sand, %	Silt, %	Clay, %	Color, dry	Color, wet
nai,	1243 0556	A	0 - 2	37.1	3.6	64.4	34.1	1.5	-	-
		$C_{1sa,cs}$	2 - 30	56.7	4.1	67.0	30.2	2.8	-	-
		$C_{2cs,sa}$	30 - 65	159.3	14.2	-	-	-	-	5YR5/8
	1845 0845		0 - 2	0.4	0	99.0	----1.0----		-	-
lim			2 - 17	0.1	0	96.8	----3.2----		-	-
			17 - 26	0.2	0	97.6	----2.4----		-	-
egev,	1478 9350		0 - 5	0.7	0	52.6	33.0	14.4	10YR7/8	10YR6/6
y			5 - 15	0.2	0	37.6	43.0	10.2	10YR7/6	19YR6/6
			15 - 20	0.3	0	68.1	22.8	9.1	10YR7/6	10YR6/6
			20 - 25	0.3	0	14.5	65.1	20.4	10YR7/6	10YR7/8
			25 - 33	0.3	0	87.4	---12.6----		10YR7/6	10YR6/8
			33 - 40	0.3	0	96.8	----3.2----		10YR7/6	10YR7/8
			40 - 50	0.3	0		-	-	10YR7/6	10YR6/8
			50 - 55	0.3	0	95.9	----4.1----		10YR7/6	10YR6/8
nai,	1040 8100		0 - 5	0.2	0	87.5	10.6	1.9	-	-
ra			5 - 10	0.2	0	86.1	12.3	1.7	-	-
			10 - 60	0.1	0	95.8	----4.2----		-	-
nai,	0000 9550	A	0 - 10	10.9	0	88.2	9.9	1.9	10YR7/4	10YR6/4
.		AC	10 - 24	30.1	0	90.9	7.2	1.9	-	-
		C_1	24 - 40	18.9	0.2	95.8	2.2	2.0	-	-
		C_1	40 - 56	14.6	0.1	95.5	3.3	1.2	-	-
		C_1	56 -110	14.0	0.3	95.6	3.0	1.4	-	-
	1845 0855	A_v	0 - 0.5	1.4	0.2	18.5	63.3	18.2	10YR7/3	10YR6/4
ılim		B	0.5- 4.5	2.1	0.2	32.0	48.7	19.3	7.5YR7/6	7.5YR6/6
		C	4.5- 35.5	16.6	8.4	42.1	52.9	5.0	10YR7/4	10YR6/4
legev,	1464 9709	B	0.3- 10	8.8	1.4	28.8	55.3	15.9	10YR7/6	10YR6/8
ı		B_{cs}	10 - 17	5.6	31.4	68.1	25.9	6.0	-	-
		C_1	17 - 40	7.3	10.6	92.4	----7.6----		-	-
legev,	1468 9114	A_v	0 - 2	0.5	0	84.9	13.4	1.7	-	-
.ey		A_1	2 - 3.5	2.4	0.2	45.2	38.0	16.8	-	7.5YR6.5/4
		B	3.5- 6	10.9	-	66.9	23.0	10.1	-	5YR4.5/6
		C_2	9 - 14	9.1	1.7	80.6	17.2	2.2	-	-
.nai,	1295 8870	A_1	0 - 1	0.7	0	59.2	32.6	8.2	10YR7/4	10YR6/4
.bila		A_2	1 - 2	1.4	0.2	26.7	55.6	17.7	-	-
		B_1	2 - 3.5	1.0	0	90.1	7.1	2.8	5YR6/8	5YR5/7
		B_{2cs}	3.5- 12	8.6	1.9	93.6	5.1	1.3	7.5YR7/4	-
		B_{2cs}	3.5- 12	0.4	0	87.5	9.6	2.9	-	-
		C	12 - 46	7.1	0.4	93.0	5.2	1.8	-	-

2

No.	Soil Type; Type of Surficial Deposit	Physiographic Unit/Landform	Pit Site	Local Parent Material	Climate (P,mm/yr)	Region, Location	Coordinates (Israel Grid)	Soil Horizon	Depth, cm	El Co
33.	Reg Soil, Holocene	Alluvial Terrace	Channel	Sandstone, Granite	Extremely Arid (20)	Eastern Sinai, Wadi K[illegible]eit	1170 6340	A_1	0 - 3	
								BC	3 - 6	
								C_1	6 - 30	
								R_S	30 - 50	
34.	Reg Soil, Pleistocene	Alluvial Terrace	-	Limestone, Dolomite, Sandstone	Extremely Arid (60)	Central Negev, Makhtesh Ramon	1330 0040	A_1	0 - 3	
								B_1	3 - 13	
								C_1	13 - 20	
								C_2	20 - 50	
35.	Reg Soil, Pleistocene	Alluvial Terrace	-	Limestone, Flint	Extremely Arid (60)	Arava Valley, Hatzeva	1758 0182	A	0 - 1	
								B_{sa}	1 - 5	
								B_{cs}	5 - 12	
								B_{sa}	12 - 20	
								C_{sa}	20 - 39	1
								C_1	39 - 52	
								C_{cs}	52 -100	
								C_2	100 -117	
								C_3	117 -135	
36.	Reg Soil, Pleistocene	Alluvial Terrace	-	Limestone, Flint	Extremely Arid (50)	Southern Negev, Wadi Paran	1460 9738	A_1	0 - 3	
								BC_1	3 - 13	
								C_2	13 - 42	
								C_3	42 - 52	
37.	Reg Soil, Pleistocene	Undulating Hill	Plateau-Hillslope Crest	Limestone, Flint	Extremely Arid (50)	Southern Negev, Nahal Hiyyon	1513 9467	A_1	0 - 2	
								A_3	2 - 6	
								B_{2cs}	6 - 21	
								B_{3cs}	21 - 38	
								B_3	38 - 50	
								C_{1ca}	50 - 76	
								C_{1cs}	78 - 94	
								C_{1cs}	94 -126	
								C_{1ca}	126 -160	
								B_b	160 -170	
38.	Reg Soil, Pleistocene	Alluvial Terrace	-	Limestone, Dolomite, Flint	Extremely Arid (50)	Southern Negev, Qetura	1560 9348	A	0 - 3	
								B_2	3 - 8	
								B_{2cs}	8 - 15	
								B_{2cs}	15 - 22	
								B_{3cs}	22 - 38	
								C_{1cs}	38 - 53	
								C_1	53 - 76	
								C_1	76 -102	
								$C_{1ca,cs}$	102 -126	
								C_1	126 -140	

Location	Coordinates (Israel Grid)	Soil Horizon	Depth, cm	Electrical Conductivity, mmho/cm	Gypsum, %	Sand, %	Silt, %	Clay, %	Color, dry	Color, wet
Sinai, ...sit	1170 8340	A_1	0 - 3	0.6	0	43.8	46.9	10.3	7.5YR8/6	7.5YR7/8
		BC	3 - 6	0.2	0	86.0	12.1	1.9	7.5YR7/8	7.5YR6/8
		C[illegible]	[illegible] - 30	2.[illegible]	0.3	98.4	----1.6----		-	-
		R_S	30 - 60	0.2	0	95.0	----5.0----		-	-
Negev, ... Ramon	1330 0040	A_1	0 - 3	6.5	0.8	43.7	43.3	13.0	10YR7/6	10YR6/6
		B_1	3 - 13	11.2	0.5	32.2	55.6	12.3	10YR7/8	10YR6/8
		C_1	13 - 20	12.8	2.3	45.7	47.3	7.0	-	-
		C_2	20 - 50	13.0	5.6	49.3	41.2	9.5	-	-
...alley,	1768 0182	A	0 - 1	41.2	0.9	47.0	43.7	9.3	10YR7/3	10YR6/8
		B_{sa}	1 - 6	64.9	0.2	50.0	43.6	6.4	7.5YR6/6	7.5YR5/6
		B_{cs}	6 - 12	12.9	29.2	57.8	23.7	18.4	-	-
		B_{sa}	12 - 20	86.5	8.1	83.2	12.5	4.3	-	7.5YR5/6
		C_{sa}	20 - 39	171.6	20.7	67.4	13.8	18.8	10YR8/1	10YR7/3
		C_1	39 - 52	33.1	0.0	92.4	6.1	1.5	10YR7/3	10YR6.5/4
		C_{cs}	52 -100	37.0	9.9	74.7	11.0	14.3	-	-
		C_2	100 -117	48.0	7.7	94.4	4.8	0.8	-	-
		C_3	117 -135	72.7	3.3	95.6	2.2	2.2	-	-
Negev, ...an	1460 9738	A_v	0 - 3	38.7	1.6	34.1	54.7	11.2	10YR7/4	10YR7/8
		BC_1	3 - 13	21.3	1.6	34.9	54.2	10.9	10YR7/6	10YR6/8
		C_2	13 - 42	19.2	11.2	60.3	30.9	8.8	7.5YR6/8	7.5YR5/8
		C_3	42 - 62	33.6	9.9	73.4	---26.7----		-	-
Negev, ...yyon	1613 9467	A_1	0 - 2	22.0	-	38.3	36.4	25.2	10YR7/4	10YR6/4
		A_3	2 - 6	31.2	1.4	53.4	34.6	12.3	7.5YR7/4	7.5YR5/6
		B_{2cs}	6 - 21	47.3	18.9	47.6	38.1	14.2	5YR6/6	5YR4/6
		B_{3cs}	21 - 38	45.2	20.5	47.2	38.8	14.0	7.5YR6/6	7.5YR5/6
		B_3	38 - 50	49.0	15.2	45.4	39.5	15.1	-	-
		C_{1cs}	50 - 78	32.2	19.4	25.4	31.2	43.4	-	7.5YR5/6
		C_{1cs}	78 - 94	56.1	24.6	31.8	42.8	25.4	7.5YR6/6	7.5YR5/6
		C_{1cs}	94 -126	53.1	21.1	38.8	48.4	12.8	-	-
		C_{1cs}	126 -160	38.9	6.7	31.2	62.0	6.8	-	7.5YR7/4
		B_b	160 -170	70.7	6.5	61.8	27.6	11.1	5YR4/8	5YR4/8
Negev,	1660 9348	A	0 - 3	8.2	0.4	46.8	38.4	14.8	7.5YR6/6	7.5YR6/6
		B_2	3 - 8	28.0	0.8	55.2	30.4	14.4	7.5YR7/4	7.5YR5/6
		B_{2cs}	8 - 15	48.8	19.5	44.0	34.8	21.1	-	-
		B_{2cs}	15 - 22	44.8	19.2	49.2	38.0	12.8	7.5YR7/4	7.5YR6/6
		B_{3cs}	22 - 38	53.5	14.6	64.8	26.4	8.8	7.5YR7/4	7.5YR6/6
		C_{1cs}	38 - 53	47.1	13.5	72.0	20.8	7.2	7.5YR7/4	7.5YR5/6
		C_1	53 - 76	48.6	7.1	83.2	10.8	6.0	-	-
		C_1	76 -102	50.2	2.0	71.2	23.2	5.6	7.5YR6/6	7.5YR4/6
		$C_{1ca,cs}$	102 -126	37.7	9.8	64.8	27.2	8.0	10YR7/4	10YR5/6
		C_1	126 -140	51.8	10.4	52.0	39.2	8.8	10YR7/4	10YR5/6

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No.	Soil Type; Type of Surficial Deposit	Physiographic Unit/Landform	Pit Site	Local Parent Material	Climate (P,mm/yr)	Region, Location	Coordinates (Israel Grid)	Soil Horizon	Depth, cm	Elec Cond mm
39.	Reg Soil, Pleistocene	Alluvial Terrace	-	Limestone, Dolomite, Sandstone	Extremely Arid (30)	Southern Negev, Timna Valley	1447 9094	A_v	0 - 2	11
								B_1	2 - 20	14
								B_2	20 - 60	37
								C_1	60 - 90	22
								C_2	90 -110	26
40.	Reg Soil, Pleistocene	Alluvial Terrace	-	Granite, Sandstone	Extremely Arid (20)	Eastern Sinai, Wadi Khuweit	1173 8348	A_v	0 - 2	12
								B	2 - 15	15
								C	15 - 70	26
41.	Reg Soil, Pleistocene	Plateau	-	Flint	Extremely Arid (30)	Central Sinai,		A_1	0 - 3	9
								A_2	3 - 9	34
								B_1	9 - 19	46
								B_{2cs}	19 - 35	86
								$B_{3sa,cs}$	35 - 47	182
								C_{1cs}	47 - 75	24
								C_{1cs}	75 -100	48
42.	Reg Soil, Pleistocene	Plateau	Plateau-Divide	Limestone, Flint	Extremely Arid (30)	Central Sinai,	000 955	A	0 - 7	10
								B_{2sa}	7 - 18	35
								B_{3sa}	18 - 25	38
								BC_{sa}	25 - 39	55
								C_{1sa}	39 - 50	38
								C_{1cs}	50 - 80	26
								C_1	80 - 95	22
								C_1	95 -120	23
43.	Reg Soil, Pleistocene	Paved Talus	Lower Talus	Dolomite, Limestone	Extremely Arid (60)	Central Negev, Makhtesh Ramon	1328 0042	A_1	0 - 5	2
								C_1	5 - 25	11
								C_2	25 - 50	7
44.	Reg Soil, Tertiary	Alluvial Terrace	-	Limestone, Flint	Extremely Arid (70)	Northern Negev, Zin Valley	1525 0332	A_v		
								B_1	2 - 10	25
								B_2	10 - 15	1[illegible]
								BC	15 - 40	11
								B_{bcs}	40 -150	15
45.	Reg Soil,	Paved Talus	Center	Basalt	Extremely	Central Negev,	1356 9977	A_1	0 - 1	6

	Coordinates (Israel Grid)	Soil Horizon	Depth, cm	Electrical Conductivity, mmho/cm	Gypsum, %	Sand, %	Silt, %	Clay, %	Color, dry	Color, wet
ev,	1447 9094	A_v	0 - 2	11.1	1.0	47.9	40.2	11.9	7.5YR6/6	7.5YR5/8
		B_1	2 - 20	14.5	16.9	53.1	43.8	3.1	7.5YR7/4	7.5YR5/8
		B_2	20 - 60	37.2	7.6	65.7	28.2	6.1	5YR6/6	5YR5/6
		C_1	60 - 90	22.5	3.2	74.2	20.4	5.4	5YR6/4	5YR5/8
		C_2	90 -110	25.6	2.2	82.3	12.3	5.5	7.5YR6/8	7.5YR5/8
1,	1173 8348	A_v	0 - 2	12.9	0.4	42.9	46.1	11.0	7.5YR8/4	7.5YR6/6
		B	2 - 15	15.5	0.9	71.1	20.3	8.6	7.5YR7/8	7.5YR5/8
		C	15 - 70	25.8	7.2	84.5	13.2	2.3	-	-
1,		A_1	0 - 3	9.4	0.1	52.4	36.4	11.3	10YR7/3	10YR5/5
		A_2	3 - 9	34.9	0.8	67.5	25.9	6.3	10YR7/3	10YR6/4
		B_1	9 - 19	46.0	0.7	73.9	20.5	5.6	7.5YR5/6	7.5YR5/6
		B_{2cs}	19 - 35	86.3	13.4	66.5	21.8	11.7	7.5YR5/6	7.5YR5/6
		$B_{3sa,cs}$	36 - 47	182.5	9.3	41.8	35.9	22.2	7.5YR6/4	7.5YR5/6
		C_{1cs}	47 - 76	24.3	43.0	-	-	-	10YR8/3	10YR6/4
		C_{1cs}	75 -100	48.1	29.4	-	-	-	10YR8/3	10YR6/4
1,	000 955	A	0 - 7	10.0	0	71.3	14.4	14.3	10YR6/4	10YR5/4
		B_{2sa}	7 - 16	36.1	0.3	53.3	42.5	4.2	5YR4/5	5YR4/5
		B_{3sa}	16 - 25	38.5	1.2	64.8	21.9	13.2	-	5YR5/6
		BC_{sa}	25 - 39	55.4	6.2	58.7	24.2	17.0	7.5YR7/4	7.5YR6/6
		C_{1sa}	39 - 50	38.6	10.2	62.8	21.9	15.3	10YR7/3	10YR6/5
		C_{1cs}	50 - 80	26.5	15.7	60.6	17.4	22.0	-	-
		C_1	80 - 95	22.8	8.1	75.7	14.8	9.6	7.5YR7/4	7.5YR6/6
		C_1	95 -120	23.9	1.5	77.6	11.0	11.4	7.5YR5/6	7.5YR5/6
ev,	1328 0042	A_1	0 - 5	2.3	0.3	47.4	40.2	12.4	10YR7/6	10YR6/8
on		C_1	5 - 25	11.3	1.2	41.9	39.8	18.3	10YR7/6-8	10YR6/8
		C_2	25 - 50	7.5	3.3	46.1	40.8	13.1	7.5YR7/8	7.5YR7/6
gev,	1526 0332	A_v								
		B_1	2 - 10	28.6	1.0	16.8	71.6	11.6	-	-
		B_2	10 - 16	12.5	5.9	16.5	60.0	23.9	-	-
		BC	15 - 40	11.9	8.6	12.2	55.5	32.3	-	-
		B_{bcs}	40 -150	18.0	28.4	41.5	34.5	24.0	-	-
ev,	1356 9977	A_1	0 - 1	6.6	0.3	40.6	51.9	7.5	10YR8/8	10YR6/8

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No.	Soil Type; Type of Surficial Deposit	Physiographic Unit/Landform	Pit Site	Local Parent Material	Climate (P,mm/yr)	Region, Location	Coordinates (Israel Grid)	Soil Horizon	Depth, cm
46.	Reg Soil, (age?)	Alluvial Terrace	-	Limestone, Flint	Extremely Arid (36)	Southern Negev, Sde Etzyon.	1246 8864	A_v	0 - 3
								B_1	5 - 10
								B_2	10 - 20
								B_3	20 - 30
								C_{cs}	30 - 50
								C_{cs}	70 - 75
47.	Reg Soil, (age?)	Paved Talus	Upper Talus	Limestone, Flint	Extremely Arid (20)	Eastern Sinai, Wadi El Qsaib	1233 8555	B_{sa}	0.2- 5
								C_{1cs}	5 - 25
								C_{2cs}	25 - 75
48.	Hammada Soil	Plateau	Plateau-Hillslope Crest	Limestone	Arid (100)	Central Negev, Mount Sagi	1155 9743	A_1	0 - 3
								B_{cs}	3 - 7
								C_{2cs}	30 - 40
49.	Hammada Soil	Rocky Hillslope	-	Limestone	Arid (100)	Central Negev, Mount Sagi	1155 9743	A_1	0 - 10
50.	Hammada Soil	Plateau	Plateau-Hillslope Crest	Limestone	Arid (100)	Central Negev, Mount Lotz	1128 9912	A_1	0 - 10
51.	Hammada Soil	Hillslope	Plateau-Hillslope Crest	Dolomite	Extremely Arid (80)	Central Negev, Hameishar	1457 9921	A_v	0 - 1
								B	1 - 10
								BC	10 - 28
								B_{cs}	28 - 50
52.	Hammada Soil	Plateau	Plateau-Hillslope Crest	Dolomite, Limestone	Extremely Arid (55)	Southern Negev, Mount Berekh	1416 9117	C_{cs}	5 - 40
53.	Lithosol	Undulating Hill	-	Chalk	Arid (90)	Judean Desert, Mitzpe Hazazon	1729 1082	A_v	0 - 2
								B	2 - 22
								C_{1cs}	22 - 44
								C_{1cs}	44 - 54
54.	Lithosol	Hillslope	-	Chalk	Arid (95)	Northern Negev, Sde Boker	1270 0310	A	0 - 35
								C	35 - 80

T)	Region, Location	Coordinates (Israel Grid)	Soil Horizon	Depth, cm	Electrical Conductivity, mmho/cm	Gypsum, %	Sand, %	Silt, %	Clay, %	Color, dry	Color, wet
ly	Southern Negev, Sde Etzyon	1246 8864	A_v	0 - 3	6.0	0.4	51.07	34.66	14.27	-	-
			B_1	5 - 10	9.0	0.7	57.07	32.71	10.22	-	-
			B_2	10 - 20	9.6	1.5	58.42	27.32	14.26	-	-
			B_3	20 - 30	10.1	2.2	61.83	26.56	11.62	-	-
			C_{cs}	30 - 50	10.1	2.2	66.41	25.19	8.40	-	-
			C_{cs}	70 - 75	[illegible].1	4.2	69.63	---30.37----		-	-
ly	Eastern Sinai, Wadi El Qsaib	1233 8666	B_{sa}	0.2- [illegible]	[illegible].8	1.8	31.7	51.5	16.5	-	7.5YR6/8
			C_{1cs}	5 - 25	17.1	16.3	-	-	-	7.5YR7-8/8	7.5YR6/8
			C_{2cs}	25 - 75	44.5	14.3	-	-	-	-	-
	Central Negev, Mount Sagi	1165 9743	A_1	0 - 3	17.2	0.9	36.3	50.2	13.5	10YR8/6	10YR7/8
			B_{cs}	3 - 7	23.5	15.8	30.0	46.1	23.9	-	10YR7/8
			C_{2cs}	30 - 40	18.3	23.5	-	-	-	10YR8/6	-
	Central Negev, Mount Sagi	1165 9743	A_1	0 - 10	0.6	0	32.5	51.0	16.5	10YR8/4	-
	Central Negev, Mount Lotz	1128 9912	A_1	0 - 10	0.4	0	29.3	60.2	10.5	10YR7/4	10YR6/6
ly	Central Negev, Hameishar	1457 9921	A_v	0 - 1	-	-	20.8	67.5	11.7	10YR7/3	-
			B	1 - 10	-	-	20.5	63.0	16.5	7.5YR8/6	-
			BC	10 - 28	-	-	33.4	46.6	19.9	7.5YR6/6	-
			B_{cs}	28 - 50	-	-	25.8	23.1	51.1	-	-
·y	Southern Negev, Mount Berekh	1415 9117	C_{cs}	5 - 40	29.0	5.7	39.0	49.5	11.5	7.5YR6/8	7.5YR5/8
	Judean Desert, Mitzpe Hazazon	1729 1082	A_v	0 - 2	1.6	-	38.1	37.6	24.3	10YR7/4	10YR5/6
			B	2 - 22	2.1	-	41.9	39.6	18.5	7.5YR7/4	7.5YR5/6
			C_{1cs}	22 - 44	-	9.9	-	-	-	-	-
			C_{1cs}	44 - 64	17.7	13.5	18.7	38.4	42.9	-	-
	Northern Negev, Sde Boker	1270 0310	A	0 - 35	1.0	3.5	29.3	41.1	29.6	10YR6/4	10YR5/4
			C	36 - 60	0.8	1.4	26.6	39.8	33.6	-	-

2

No.	Soil Type; Type of Surficial Deposit	Physiographic Unit/Landform	Pit Site	Local Parent Material	Climate (P,mm/yr)	Region, Location	Coordinates (Israel Grid)	Soil Horizon	Depth cm
55.	Lithosol	Hillslope	Center Hillslope	Chalk	Arid (95)	Northern Negev, Sde Boker	1270 0310	A	0 -
								BC	30 -
								C_1	55 -
								C_{2cs}	70+
56.	Lithosol	Hillslope	Center Hillslope	Chalk	Arid (95)	Northern Negev, Sde Boker	1270 0310	A	0 -
								C_1	20 -
								C_2	35 -
57.	Serozem Soil	Alluvial Terrace	-	Coarse Alluvium	Arid (130)	Jordan Valley	1953 1467	A_1	0 -
								A_3	10 -
								AC	26 -
								C_{1cs}	50 -
								C_{1cs}	62 -1
								C_{1cs}	101 -1
								C_{1cs}	124 -1
								C_{1cs}	138 -1
								C_{1cs}	157 -1
								IIC_2	174 -2
								IIC_2	219 -2
58.	Serozem Soil	Plateau	Plateau-Hillslope Crest	Flint	Moderately Arid (230)	Judean Desert, Rujm En Naga	1764 1045	A	0 -
								B_{2ca}	22 -
								B_{2ca}	40 -
								B_{3cs}	60 -
								BC_{cs}	71 -
								IIC_{cs}	98+
59.	Gravelly Regosol	Sieve Deposit Talus	Upper Talus	Igneous, Acid Volcanic	Extremely Arid (30)	Southern Negev, Mount Amram	1465 8985	C_1	10 -
								C_2	30 -
60.	Gravelly Regosol	Sieve Deposit Talus	Center Talus	Igneous, Acid Volcanic	Extremely Arid (30)	Southern Negev, Mount Amram	1465 8985		5 -
									27 -
61.	Gravelly Regosol	Sieve Deposit Talus	-	Igneous, Acid Volcanic	Extremely Arid (30)	Southern Negev, Mount Amram	1453 8975	A_v	0 -
								C_1	30 -
								C_2	70 -
								C_2	95 -1
62.	Gravelly Regosol	Sieve Deposit Talus	Center Talus	Granite, Igneous, Metamorphic, Limestone, Sandstone	Extremely Arid (25)	Eastern Sinai, Wadi Mukeibila	1288 8650	S	40 -
								S	60 -

Region, Location	Coordinates (Israel Grid)	Soil Horizon	Depth, cm	Electrical Conductivity, mmho/cm	Gypsum, %	Sand, %	Silt, %	Clay, %	Color, dry	Color, wet
Northern Negev, Sde Boker	1270 0310	A	0 - 10	0.6	-	48.7	22.2	28.7	10YR7/4	10YR6/4
		BC	30 - 55	10.0	0.6	28.5	18.6	52.9	-	-
		C_1	[illegible] - 70	9.0	0.6	33.4	17.4	49.2	-	-
		C_{2cs}	70+	11.0	2.2	22.7	23.5	56.8	-	-
Northern Negev, Sde Boker	1270 0310	A	0 - 20	0.4	-	43.6	24.1	32.3	10YR7/4	10YR5/4
		C_1	20 - 35	1.3	-	44.9	17.0	38.1	10YR7/4	10YR6/4
		C_2	35 - 60	2.8	-	47.7	14.5	38.7	10YR8/4	10YR7/4
Jordan Valley	1953 1487	A_1	0 - 10	41.0	-	59.2	17.8	20.7	10YR7/3	10YR6/4
		A_3	10 - 25	37.0	0.1	42.2	21.8	33.5	10YR7/3	10YR6/4
		AC	26 - 60	36.9	0.2	32.4	22.6	42.1	-	-
		C_{1cs}	60 - 62	28.0	2.4	22.2	32.0	41.0	-	-
		C_{1cs}	62 - 101	24.4	2.8	26.4	30.8	39.4	-	-
		C_{1cs}	101 - 124	26.7	3.5	10.0	40.0	54.7	5R8/2	5R7/2
		C_{1cs}	124 - 138	27.3	3.6	24.0	32.4	38.0	-	-
		C_{1cs}	138 - 157	29.4	3.7	34.0	26.4	34.4	10YR8/3	10YR8/3
		C_{1cs}	157 - 174	23.0	3.7	43.8	20.2	25.2	5Y8/1	5Y7/2
		IIC_2	174 - 219	27.3	3.8	33.2	26.0	35.7	5Y8/2	5Y7/3
		IIC_2	219 - 290	23.9	3.8	17.8	30.2	46.4	5Y6/1	5Y7/2
Judean Desert, Rujm En Naqa	1764 1045	A	0 - 22	1.0	-	30.8	42.0	27.2	10YR6/4	7.5YR5/6
		B_{2ca}	22 - 40	3.4	-	14.7	46.8	38.5	7.5YR5/4	7.5YR5/4
		B_{2ca}	40 - 60	8.8	0.6	19.8	36.4	43.8	7.5YR5/4	7.5YR5/4
		B_{3cs}	60 - 71	17.2	23.0	17.6	33.1	49.3	7.5YR5/4	7.5YR5/4
		BC_{cs}	71 - 98	20.8	23.0	23.7	31.3	45.0	10YR7/4	10YR6/4
		IIC_{cs}	98+	8.2	44.0	26.0	[illegible]	57.5	7.5YR7/2	7.5YR8/4
Southern Negev, Mount Amram	1465 8985	C_1	10 - 30	15.8	1.8	47.7		12.0	10YR6/6	10YR6/8
		C_2	30 - 60	2.9	2.5	66.8		4.8	10YR[illegible]/6	10YR6/6
Southern Negev, Mount Amram	1465 8986		5 - 12	0.3	0	50.5	40.4	9.1	10YR7/6	7.5YR6/6
			27 - 42	0.2	0	51.2	43.0	5.8	10YR7/6	10YR6/6
Southern Negev, Mount Amram	1453 8975	A_v	0 - 2	0.4	0	50.6	42.7	6.7	10YR7/6	10YR5/8
		C_1	30 - 50	0.3	0	51.1	38.9	10.0	10YR6/6	10YR6/8
		C_2	70 - 95	17.4	1.1	68.5	24.3	7.2	10YR6/4	10YR4/6
		C_2	95 - 135	17.4	3.3	56.5	35.0	8.5	10YR6/4	7.5YR6/4-6
Eastern Sinai, Wadi Mukeibila	1298 8660	S	40 - 60	1.2	1.8	66.9	27.5	5.5	-	-
		S	60 - 100	37.6	3.2	61.2	31.0	7.8	-	-

No.	Soil Type; Type of Surficial Deposit	Physiographic Unit/Landform	Pit Site	Local Parent Material	Climate (P,mm/yr)	Region, Location	Coordinates (Israel Grid)	Soil Horizon	Depth, cm
63.	Dune Sand	Active Dune	5	Sand	Arid (100)	Western Negev, Mount Qeren	1003 0460		1 - 3
			4				1003 0460		-
			2				1005 0460		-
			6				1003 0460		-
64.	Dune Sand	Active Dune	-	Sand	Extremely Arid (32)	Arava Valley, Yotvata	1567 9242		0 - 5
65.	Alluvial Sand	Undulating Hill	Plateau-Divide	Sand	Semi-arid (325)	Western Negev, Be'eri	1003 0921	A	0 - 48
								B_{ca}	48 -106
								C_1	106 -136
								C_2	136 -180
66	Alluvial Sand	Undulating Hill	-	Sand	Semi-arid (300)	Western Negev, Kissofim	0946 0916	A	0 - 26
								B_{ca}	26 - 73
								B_{ca}	73 -103
								C_{1ca}	103 -143
								C_{1ca}	143 -210
								C_2	210 -260
								C_2	260 -300
67.	Alluvial Sand	Hillslope	Plateau-Hillslope Crest	Sand	Semi-arid (300)	Western Negev, Kissofim	0947 0915	A	0 - 31
								B_{ca}	31 - 80
								C_1	80 -101
								C_2	101 -175
68.	Sandy Regosol	Stabilize Dune	-	Sand	Moderately Arid (180)	Western Negev, Yamit	0725 0725	A	0 - 40
								C_{1ca}	40 -100
								C_{1ca}	100 -140
								C_2	140 -190
								C_2	190 -250
69.	[illegible] Alluvial Soil	Alluvial Fan	Upper Fan	Coarse Alluvium	Semi-arid (250)	Jordan Valley, Fatzael	1918 1615	A	0 - 17
								B_{2ca}	17 - 44
								B_{2ca}	44 - 70
								B_{2ca}	70 -112
								C	112 -150
70.	Brown Alluvial Soil	Alluvial Fan	Upper Fan	Lisan Marl	Arid (150)	Jordan Valley,	1921 1361		0 - 8
									8 - 24
									24 - 62
									62 -115
									115 -122
									122 -144

lon, ation	Coordinates (Israel Grid)	Soil Horizon	Depth, cm	Electrical Conductivity, mmho/cm	Gypsum, %	Sand, %	Silt, %	Clay, %	Color, dry	Color, wet
tern Negev, ni qeren	1003 0460		1 - 3	0.5	0	99.4	----0.6----		-	-
	1003 0460		-	0.4	0	99.4	----0.6----		-	-
	1005 0460		-	0.2	0	92.9	----7.1----		-	-
	1003 0460		-	0.6	0	98.8	----1.2----		-	-
va Valley, vata	1567 9242		0 - 6	0.8	0	97.4	----2.6----		7.5YR6/6	7.5YR7/6
tern Negev, eri	1003 0921	A	0 - 48	0.4	-	71.1	18.9	10.0	10YR6/4	10YR6/6
		B_{ca}	48 -108	0.3	-	71.4	19.8	8.8	9YR6/4	10YR4/6
		C_1	108 -136	0.3	-	88.9	6.4	4.7	10YR6/4	10YR6/8
		C_2	136 -180	0.3	-	94.6	2.8	2.6	10YR7/4	-
tern Negev, sofim	0946 0916	A	0 - 26	0.4	-	84.4	8.8	6.8	10YR5/4	10YR4/4
		B_{ca}	26 - 73	0.3	-	83.3	9.7	7.0	10YR6/4	10YR5/4
		B_{ca}	73 -103	0.3	-	91.6	4.5	3.9	-	10YR5/6
		C_{1ca}	103 -143	0.3	-	96.7	1.6	1.7	10YR6.5/4	10YR5/6
		C_{1ca}	143 -210	0.3	-	98.1	0.5	1.4	-	-
		C_2	210 -260	0.3	-	97.6	1.0	1.4	-	-
		C_2	260 -300	0.3	-	97.0	1.7	1.3	-	-
tern Negev, sofim	0947 0915	A	0 - 31	0.3	-	80.0	11.1	8.9	10YR6/4	10YR5/4
		B_{ca}	31 - 80	0.3	-	83.7	9.1	7.2	10YR6/4	10YR5/6
		C_1	80 -101	0.2	-	93.7	3.0	3.3	10YR6/4	10YR5/6
		C_2	101 -175	0.2	-	96.7	1.9	1.4	-	10YR5.5/4
tern Negev, it	0726 0726	A	0 - 40	0.3	-	88.2	6.2	5.6	10YR7/4	10YR6/4
		C_{1ca}	40 -100	0.3	-	84.3	8.6	7.1	-	-
		C_{1ca}	100 -140	0.2	-	86.0	7.6	6.6	-	-
		C_2	140 -190	0.2	-	90.8	4.7	4.6	-	-
		C_2	190 -250	0.3	-	84.2	10.8	5.0	-	-
dan Valley, rael	1918 1610	A	0 - 17	1.8	-	62.0	22.0	16.0	10YR7/3	10YR5/4
		B_{2ca}	17 - 44	1.4	-	49.0	29.0	22.0	7.5YR6/4	7.5YR5/4
		B_{2ca}	44 - 70	0.8	-	59.4	22.0	18.6	-	-
		B_{2ca}	70 -112	0.9	-	72.0	13.6	14.4	7.5YR6/4	7.5YR5/4
		C	112 -150	2.0	-	78.4	10.6	10.9	-	-
dan Valley,	1921 1361		0 - 8	2.0	-	76.0	12.2	11.7	10YR7/3	10YR6/4
			8 - 24	2.1	-	63.6	23.0	13.3	10YR7/3	10YR6/4
			24 - 62	2.0	-	79.6	9.8	10.5	10YR7/3	10YR6/4
			62 -115	6.0	-	81.0	10.0	8.8	10YR7/3	10YR6/4
			115 -122	7.8	-	51.2	25.4	22.9	10YR8/3	10YR7/3
			122 -144	10.7	-	55.4	23.0	21.1	10YR7/3	10YR6/4

2

No.	Soil Type; Type of Surficial Deposit	Physiographic Unit/Landform	Pit Site	Local Parent Material	Climate (°,mm/yr)	Region, Location	Coordinates (Israel Grid)	Soil Horizon	Depth, cm
71.	Brown Alluvial Soil	Alluvial Terrace	Lower Fan	Lisan Marl	Arid (130)	Jordan Valley,	1942 1358		0 - 10
									10 - 30
									30 - [illegible]
									63 - 7[illegible]
									76 - 90
									90 -108
									108 -17[illegible]
72.	Brown Alluvial Soil	Alluvial Fan	-	Lisan Marl	Arid (150)	Jordan Valley,	1935 1330	A	0 - 1[illegible]
								C_1	19 - 4[illegible]
								C_1	40 - 75
								C_1	75 -107
								C_1	107 -14[illegible]
								C_{ca}	140 -163
								IIC_2	153 -180
73.	Grumusol	Hillslope	-	-	Semi-arid (400)	Western Negev	1078 1018	A	0 - 16
								B_1	16 - 30
								B_2	30 - 67
								B_2	67 -120
								B_{2ca}	120 -160
								B_{2ca}	160 -200
74.	Grumusol	Plateau	-	Limestone	Semi-arid (350)	Eastern Samarian Mountains, Ma'ale Efraim	1865 1665	A	0 - 10
								B_1	10 - 40
								B_2	40 - 75
								B_2	75 -125
								B_2	125 -165
								B_2	165 -200
75.	Grumusol	Active Flood-plain	-	Fine Alluvium	Moderately Arid (200)	Jordan Valley	1982 1703	A_1	0 - 4
								A_3	4 - 21
								B_2	21 - 45
								B_2	45 - 80
								B_2	80 -120
								B_3	120 -160

on. ation	Coordinates (Israel Grid)	Soil Horizon	Depth, cm	Electrical Conductivity, mmho/cm	Gypsum, %	Sand, %	Silt, %	Clay, %	Color, dry	Color, wet
lan Valley,	1942 1356		0 - 10	6.1	-	60.2	27.2	12.4	10YR8/2	10YR7/3
			10 - 30	31.7	-	58.0	25.0	16.7	10YR7/3	10YR6/4
			30 - 63	31.7	-	78.2	12.4	8.1	10YR7/3	10YR6/4
			63 - 76	26.4	-	94.0	4.0	1.0	10YR8/2	10YR7/2
			76 - 90	23.5	-	93.0	3.8	2.2	10YR7/2	10YR6/3
			90 -108	22.7	-	32.4	37.8	27.9	10YR8/2	10YR7/1
			108 -170	34.0	-	30.0	42.2	24.6	10YR8/3	10YR8/3
lan Valley.	1935 1330	A	0 - 19	18.6	-	68.4	19.4	11.6	10YR7/3	10YR5/4
		C_1	19 - 40	19.4	-	70.2	20.0	8.9	10YR7/3	10YR5/4
		C_1	40 - 76	20.4	-	74.6	18.8	5.8	10YR7/3	10YR6/4
		C_1	76 -107	15.8	-	74.4	18.4	8.4	10YR7/3	10YR6/4
		C_1	107 -140	14.3	-	71.6	16.0	11.7	10YR7/3	10YR6/4
		C_{ca}	140 -163	16.3	-	22.4	51.2	25.2	-	-
		IIC_2	163 -180	14.6	-	13.2	51.2	34.5	-	-
ern Negev	1078 1018	A	0 - 16	0.6	-	23.8	33.9	42.3	7.5YR5/4	7.5YR4/4
		B_1	16 - 30	0.4	-	21.4	34.7	43.9	-	-
		B_2	30 - 67	0.6	-	20.4	34.6	45.0	7.5YR5/4	7.5YR4/4
		B_2	67 -120	1.7	-	16.0	33.4	50.6	-	-
		B_{2ca}	120 160	3.0	-	15.4	33.2	51.4	-	-
		B_{2ca}	160 -200	3.0	-	13.9	32.7	53.4	5YR4/4	5YR4/4
ern Samarian	1865 1665	A	0 - 10	0.4	-	9.1	31.3	59.6	5YR4/4	5YR4/4
tains,		B_2	10 - 40	0.3	-	10.4	28.5	61.1	5YR4/4	5YR4/4
le Efraim		B_2	40 - 76	0.3	-	10.0	31.0	59.0	-	-
		B_2	76 -125	0.4	-	8.1	31.4	60.5	-	-
		B_2	125 -165	0.9	-	5.9	32.3	61.8	5YR3/4	5YR3/4
		B_2	165 -200	1.0	-	8.4	30.4	61.2	5YR3/4	5YR3/4
lan Valley	1982 1703	A_1	0 - 4	2.0	-	43.4	18.4	38.1	10YR5/4	10YR4/3
		A_3	4 - 21	0.5	-	38.2	21.4	40.4	10YR6/4	10YR4/3
		B_2	21 - 46	0.5	-	24.4	32.4	43.2	7.5YR4/4	7.5YR4/4
		B_2	46 - 80	0.6	-	24.0	32.6	43.4	7.5YR4/4	7.5YR4/4
		B_2	80 -120	0.9	-	22.2	33.8	43.9	7.5YR5/4	-
		B_3	120 -160	1.6	-	25.4	34.4	40.1	-	-

TABLE G.3.2

ADDITIONAL SOIL PROFILES INCLUDED IN THE REPORT — SOIL TYPES, LOCATION, NUMBER OF PROFILES.

Soil Type; Type of Surficial Deposit	Physiographic Unit; Landform	Region; Location	Coordinates (Israel Grid)	No. of Profiles
Loessial Soil	Hillslope	Western Negev	0913 0822	1
	Hillslope	Northern Negev, Sde Boker	1270 0310	1
	Eolian Plain	Northern Negev, Sde Boker	1306 0309	1
Brown Loessial Soil	Hillslope	Western Negev	1165 1184	1
Light Brown Loessial Soil	Hillslope	North Eastern Negev, Qriot	1609 0818	1
	Hillslope	North Eastern Negev, Qriot	1624 0835	1
	Hillslope	North Eastern Negev, Qriot	1623 0830	1
	Hillslope	Western Negev	1124 0950	1
	Badlands	Western Negev	1012 0938	1
	Alluvial Terrace	Western Negev	0995 0897	1
Loessial Serozem Soil	Undulating Hill	Northern Negev, Tel Arad	1624 0751	1
	Hillslope	Northern Negev, Tel Arad	1589 0764	1
	Hillslope	Northern Negev, Tel Arad	1605 0762	2
	Hillslope	Western Negev	0972 0828	1
	Hillslope	Northern Negev, Sde Boker	1270 0310	1
	Eolian Plain	Northern Negev, Sde Boker	1310 0305	4
Loess	Archeological Site	Central Negev, Makhtesh Ramon	1440 0016	1
Loess	Archeological Site	Northern Negev, Tel Arad	1620 0767	1
Loess	Archeological Site	Southern Negev, Uvda Valley	1464 9286	1
Takyr Soil	Playa	Southern Negev, Qetura	1580 9397	1
	Playa	Southern Negev, Qa En Naqb	1350 8915	1
Solonchak Soil	Alluvial Fan	Dead Sea, Ein Tamar	1845 0440	2
	Plateau Divide	Eastern Samarian Mts., Ma'ale Efraim	1890 1640	1
	-	Jordan Valley	1972 1343	1
	Playa	Jordan Valley	1935 1587	1
	Playa	Southern Arava, Arvona Playa	1510 8956	2
	Sabkha	Eastern Sinai, Wadi Khumeira	1325 8704	3
	Playa	Eastern Sinai, Bir Sweir	1243 8556	2
Colluvium	Colluvial Hillslope	Western Negev, Mount Qeren	1005 0460	1
	Debris Flow Talus	Eastern Sinai, Magrish	1305 8690	1

Soil Type; Type of Surficial Deposit	Physiographic Unit; Landform	Region; Location	Coordinates (Israel Grid)	No. of Profiles
Alluvium	Active Floodplain	Dead Sea, Nahal Ze'elim	1845 0845	1
	Active Floodplain	Central Negev, Makhtesh Ramon	1325 0020	1
	Active Floodplain	Arava Valley, Yotvata	1567 9242	1
	Active Floodplain	Southern Negev, Nahal Paran	1450 9708	1
	Active Floodplain	Southern Negev, Uvda Valley	1470 9353	1
	Alluvial Fan	Southern Negev, Mount Amran	1457 8169	1
	Active Floodplain	Eastern Sinai, Wadi Khmeira	1314 8884	1
	Active Floodplain	Eastern Sinai, Wadi Mandara	1040 8100	1
	Active Floodplain	Eastern Sinai, Bir Sa'al	0745 7968	1
Reg Soil, Holocene	Alluvial Terrace	Arava Valley, Hatzeva	1780 0196	1
	Alluvial Terrace	Central Sinai	0000 9551	1
	Alluvial Fan Terrace	Dead Sea, Nahal Ze'elim	1845 0855	6
	Alluvial Fan Terrace	Dead Sea, Nahal Ze'elim	1835 0858	2
	Alluvial Fan Terrace	Dead Sea, Nahal Ze'elim	1845 0848	8
	Alluvial Fan Terrace	Dead Sea, Nahal Ze'elim	1838 0848	4
	Alluvial Fan Terrace	Dead Sea, Nahal Ze'elim	1845 0843	13
	Alluvial Fan Terrace	Dead Sea, Nahal Ze'elim	1842 0847	5
	Alluvial Fan Terrace	Dead Sea, Nahal Ze'elim	1848 0836	5
	Alluvial Terrace	Central Negev, Zin Valley	1412 0260	1
	Alluvial Terrace	Central Negev, Makhtesh Ramon	1504 0027	1
	Alluvial Terrace	Central Negev, Makhtesh Ramon	1325 0020	2
	Alluvial Terrace	Southern Arava, Nahal Odem	1508 9172	[illegible]
	Alluvial Terrace	Southern Negev, Timna Valley	1468 9114	[illegible]
	Alluvial Fan	Southern Negev, Mount Amram	1457 8969	1
	Alluvial Fan Terrace	Eastern Sinai, Wadi Mukeibila	1295 8665	5
	Debris Flow Fan	Eastern Sinai, Wadi Mukeibila	1290 8650	3
	Alluvial Terrace	Eastern Sinai, Wadi Khuweit	1150 8342	2
	Active Talus	Eastern Sinai, Wadi Mandara	1040 8100	3
Reg Soil, Pleistocene	Alluvial Terrace	Arava Valley, Ein Yahav	1742 0106	1
	Alluvial Terrace	Central Negev, Zin Valley	1480 0335	1
	Alluvial Terrace	Central Negev, Zin Valley	1505 0340	2
	Alluvial Terrace	Central Negev, Makhtesh Ramon	1340 0040	1
	Alluvial Plain	Arava Valley, Hatzeva	1730 0203	1
	Plateau-Divide	Southern Negev, Nahal Yaalon	1552 9428	1
	Alluvial Terrace	Southern Negev, Nahal Paran	1452 9717	1
	Alluvial Terrace	Southern Negev, Nahal Odem	1504 9168	2
	Alluvial Terrace	Southern Negev, Timna Valley	1460 9110	3
	Alluvial Fan	Southern Negev, Nahal Yael	1444 8893	1
	Alluvial Fan	Southern Negev, Qa En Naqb	1350 8924	4
	Alluvial Terrace	Eastern Sinai, Wadi Mukeibilia	1287 8678	3
	Alluvial Terrace	Eastern Sinai, Wadi Khuweit	1178 8349	7
	Alluvial Terrace	Eastern Sinai, Wadi Thamila	1123 8362	2
	Alluvial Terrace	Eastern Sinai, Wadi Abu Ruta	1204 8755	1

Soil Type; Type of Surficial Deposit	Physiographic Unit; Landform	Region; Location	Coordinates (Israel Grid)	No. of Profiles
Reg Soil, Pleistocene	Talus Relict	Central Negev, Makhtesh Ramon	1332 0041	1
	Paved Talus	Central Negev, Makhtesh Ramon	1315 0018	3
	Paved Talus	Central Negev, Makhtesh Ramon	1328 0042	3
	Paved Talus	Arava Valley, Paran	1668 9739	2
	Paved Talus	Southern Negev, Mount Amram	1465 8985	2
	Paved Talus	Eastern Sinai, Bir Sa'al	0745 7968	2
	Debris Flow Talus	Eastern Sinai, Siket Niqbein	0744 7918	1
	Paved Talus	Eastern Sinai, Siket Niqbein	0744 7918	1
Reg Soil (age?)	Alluvial Terrace	Dead Sea, Mitzpe Hatzatzon	1835 1075	1
	Alluvial Terrace	Eastern Sinai, Wadi Sa'ada	1140 8208	3
	Paved Talus	Eastern Sinai	1233 8555	3
	Alluvial Terrace	Eastern Sinai, Bir Zreir	1090 8045	4
	Rockfall Talus	Eastern Sinai, Bir Zreir	1095 8055	2
Hammada Soil	Plateau	Eastern Samarian Mts., Ma'ale Efraim	1597 0390	1
	Plateau-Hillslope Crest	Central Sinai, Makhtesh Ramon	1185 9937	1
	Rocky Hillslope	Central Negev, Mount Lots	1128 9912	1
	Plateau-Divide	Southern Negev, Mount Amram	1460 8970	1
Lithosol	Plateau-Hillslope Crest	Judean Desert, Bani Naim Ridge	1715 1120	1
	Andulating Hill	Dead Sea, Mitzpe Hatzatzon	1868 1085	1
	Hillslope	Northern Negev, Sde Boker	1270 0310	10
Serozem Soil	Alluvial Terrace	Jordan Valley	2010 1985	1
Gravelly Regsol	Sieve Deposite Talus	Southern Negev, Mount Amram	1465 8985	1
	Debris Flow Talus	Eastern Negev, Wadi Khmeira	1311 8685	3
	Sieve Deposit Talus	Eastern Negev, Wadi Khmeira	1288 8650	2
Saline Brown Clayey Regosol	Hillslope	Western Negev	1015 0940	2
Alluvial Sand	Alluvial Terrace	Western Negev, Mount Qeren	1003 0460	1
Brown Alluvial Soil	Hillslope	North Eastern Negev, Qriot	1624 0830	2
	Alluvial Terrace	Jordan Valley	1953 1467	1
	Alluvial Fan	Jordan Valley	1925 1575	1
	Playa	Jordan Valley	1932 1584	1
	Alluvial Fan	Jordan Valley	1947 1604	1
Grumusol	Plateau-Saddle	Eastern Samaria Mts., Ma'ale Efraim	1860 1650	1
	Plateau-Hillslope Crest	Western Negev	1165 1185	1
	Hillslope	Western Negev	1163 1181	1

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APPENDIX 3 GLOSSARY

Note: The following terms are defined for application in the context of the present report. In some cases the definitions are not sufficient for general use. The emphasis here is on terrains of the hot deserts.

Acid Volcanic Rocks Igneous rocks that have been poured out or ejected at or near the earth's surface, having a higher percentage of silica than orthoclase, the limiting figure commonly adopted being 60%.

Aggregate A group of primary particles intimately bound such that they form secondary units.

A Horizon (in desert soils) A mineral soil horison formed at or adjacent to the surface.

Alluvium An unconsolidated sediment deposited by a stream or a river (a fluvial sediment). Composed of gravel, sand, silt, clay.

Badlands An extremely dissected landscape, characterized by very fine drainage network, usually carved in unconsolidated or poorly cemented materials such as silt, clay, shale, chalk, volcanic ash. Lack of vegetation, steep gradients and erodible materials are favorable enviromental conditions for badland formation.

Bajada or Bahada The nearly flat surface of a continuous apron consisting of confluent alluvial fans which together with the pediment make up the piedmont slope in a basin.

Ballena A major landform comprising distinctively round topped ridgeline remnants of fan alluvium. The ridge's broadly rounded shoulders meet from either side to form a narrow crest and merge smoothly with the concave backslopes.

Basalt A general term for dark colored mafic igneous rocks, commonly extrusive but locally intrusive, composed chiefly of calcic plagioclase and clinopyroxene; the fine grained equivalent of gabbro.

B Horison (in desert soils) A mineral soil horison in which the parent sediment or rock structure and texture has distinctly changed, charachterised by: (a) an illuvial concentration of silt, clay and occasionly fine sand; (b) weathering of certain minerals and iron released as oxides/hydroxides; (c) some new structure has formed; (d) usually shows accumulation of salts, gypsum or carbonate.

Brown Alluvial Soil A brown soil formed of young alluvial deposits in valley floors. The texture is loamy and often contains $CaCO_3$.

Brown and Light Brown Loessial Soils A soil formed of eolian or fluvial loess usually with an $AB_{ca}C$ or an $AB_{ca}B_b$ profile. The texture is sandy-loam, loam or clay-loam. It contains $CaCO_3$ nodules throughout most of the profile.

Buried Soil/Horizon A soil or an horizon (B or C) is considered to be buried if there is a surface mantle or if it is overlain by a mantle of new material. (see palesol)

ca-Calcic Horizon A soil horison with a secondary concentration of $CaCO_3$, of at least 5% by weight.

Chalk A very soft, white to light gray, unindurated limestone composed of the tests of floating microorganisms and

some bottom dwelling forms in a matrix of finely crystalline calcite. Some chalk can be almost devoid of organic remains.

C Horizon A mineral soil horizon or a layer underlying B horizon (q.v.), usually similar in structure and texture to the parent sediment or rock, but weathered and unconsolidated.

Clay A soil or sediment separate consisting of particles $<$ 0.002mm in (equivalent) diameter. Fine clay — $<$ 0.001mm.

Climatic Regimes of the hot deserts are here subdivided accordingly to the mean annualy precipitation as folows: (a) **semi-arid** — 400-250 mm/year; (b) **moderately arid** — 250-150 mm/year; (c) **arid** — 150-80 mm/year; (d) **extremly arid** — <80 mm/year.

Colluvium Colluvium is the superficial mantle of unconsolidated rock debris which consists of hetrogeneous materials of any particle size which accumulate on the lower parts or the base of slopes.

cs-Gypsic Horizon A soil horizon with a visible secondary concentration of gypsum, usually more than 5%.

Debris Flow A dense (60–80% solids, by weight), viscous and rapid flow consisting of coarse particles embeded in fine material. It usually begins on unvegetated talus or colluvial slopes during extremely heavy precipitation. The deposits are unstratified, poory sorted with coarse particles matrix supported in elongated, lobate forms. Commonly coarse particles armour the surface and form low ridges (levees) bordering the flow.

Debris Flow Fan see: Fan — Debris Flow.

Desert Pavement Desert pavement is a type of surficial cover composed of $\geq$ 40% gravel, overlying a fine earth (silt, fine sand, clay) horizon. The gravel is usually mechanically shattered and flat lying.

Divide A belt of separation between drainage systems: the summit of an interfluve.

Dolomite A carbonate sedimentary rock of which more than 50% consists of the mineral dolomite, or a variety of limestone or marble rich in magnesium carbonate.

Dune Mound or ridge of wind blown (or eolian) unconsilidated sand.

- **Sand dune** — An eolian dune and a landform element built of sand size mineral particles.
- **Stabilised dune** — A non-active dune stabilised by vegetation and penetrating airborne dust and salts.
- **Climbing dune** — A dune climbing on a hillslope.

Dust — Desert Dust The material in surficial deposits (including soils) and in the atmosphere composed of particles smaller than 0.0625mm. It consists mostly of silt size particles (0.002–0.0625mm in diameter) with lesser amounts of clay (<0.002mm) and may include some very fine sand (0.0625–0.125mm). Dust can remain in suspension in the atmosphere for long periods of time and be transported for long distances.

Electrical Conductivity (in soils) Electrical conductivity is a measure for the concentration of soluble salts in soils. Electrical conductivity is reciprocal of electrical resestivity. The dimensions are 1/ohm cm or mho per cm. The conventionally used units for soil solution or extract are millimho/cm. The standard temperature for reporting electrical conductivity measurements is

25°C.

Fan — Alluvial An alluvial fan is a body of stream deposits whose surface approximates a segment of a cone that radiates downslope from the point where the stream leaves a mountaineous area. Alluvial fans have greatly diverse sizes, slopes, types of deposits and source-area characteristics. They are most widespread in the dried parts of the world.

Fan — Debris flow An accumulation of debris brought down by a debris flow descending through a steep raving and debouching in the plain beneath where the detritial material spreads out in the shape of a fan.

Fine Earth The textural separate of the soil which includes sand, silt and clay.

Flint (Chert) A hard, extremely dense or compact, dull to semivitreous microcrystalline or cryptocrystalline sedimentary rock, consisting dominantly of interlocking crystals of quartz. It may contain amorphous silica, and impurities such as calcite, iron oxide and remains of siliceous and other organisms.

Flood Plain A geomorphic feature formed by stream/river, it represents the area in which the stream/river flows, erodes and deposits in time of flood. A flood plain is composed of channel and overbank deposits.

Granite A term loosely applied to any light colored coarse grained plutonic rock containing quartz as an essential component, along with feldspar and mafic minerals.

Gravel Sediment or soil particles coarser than 2mm in diameter. Subdivision of gravel: granule - 2-4mm; pebble - 4-64mm; cobble - 64-256mm; boulder - >256mm.

Grus Angular fragments of crystal grain size produced locally by weathering of coarse crystaline rocks, frequently granite.

Hammada A shallow soil developed in situ, usually on hard bedrock on gently sloping terrains, covered by angular rock fragment. The profile includes ABR, ACR, or ABCR horizons (often gypsic or saline).

Hillslope The inclined surface of a hill, mountain plateau, plain or any part of the surface of the earth. Slope is also the angle at which such a surface deviates from the horizontal.

Holocene (Recent) An epoch of the Quaternary (q.v.) period, from the end of the Pleistocene (q.v.), approximately 10,000 years ago, to the present time.

Igneous Rocks A rock that solidified from molten or partly molten materiel, i.e. from magma.

Limestone A sedimentary rock consisting chiefly (more than 50%) of calcium carbonate, primarily in the form of the mineral calcite, and or without magnesium carbonate.

Lithosol A shallow soil with no well developed AC, ACR, C or CR horizons. Usully formed on soft, friable bedrock, often gravelly and saline.

Loam Soil material or deposit which contains 7-27% clay, 28-50% silt, <52% sand (see figure 1C in chapter C.1).

Loess Material transported and deposited by wind and consisting of predominantly silt with some very fine sand and clay particles.

Loessial Serozem Soil A soil developed of loess parent material. Very Light brown or yellowish brown in color, usually sandy loam or loam in texture. Contains carbonate nodules and at depth

gypsum and salts.

Loessial Soil A soil developed from loess parent material. In many cases it forms on alluvial loess, derived from primary eolian deposits. The texture is loam, silty loam or fine sandy loam.

Marl An old term loosely applied to a variety materials, most of which occur as loose, earthy deposits consisting chiefly of an intimate mixture of clay and calcium carbonate, formed under marine or freshwater conditions. 35–65% clay; 65–35% carbonate.

Metamorphic Rocks Any rock derived from pre-existing rocks by minerological, chemical and/or structural changes, essentially in the solid state, in response to marked changes in temperature, pressure, shearing stress and chemical environment, generally at depth in the Earth's crust.

Paleosol A soil which have formed in landscapes of the past (see also buried soil/horizon).

Plain A region of general uniform slope, comparatively level of considerable extent, and not broken by marked elevations & depressions: it maybe an extensive valley floor or a plateau summit. A plain is here defined as an extensive area having relief $\leq$ 20m and gradients of $<10^{\circ}$.

Plateau A relatively elevated area of comparatively flat land which is commonly limited on at least one side by an abrupt descent to lower land.

Playa An ephemerally flooded usually barren area on a basin floor that is veneered with fine textured sediments and/or salts. Acts as a temporary or the final sink for drainage water.

Pleistocene An epoch of the Quaternary (q.v.), between the Pliocene of the Tertiary (q.v.) and before the Holocene (q.v.). It began approximately 1.8 million years ago and lasted until the Holocene came 10,000 years ago.

Quaternary The second period of the Cenozoic era, following the Tertiary. It began approximately 1.8 million years ago and extends to the present. It consists of the Pleistocene (q.v.) and the Holocene (q.v.) periods.

Regosol A deep soil with AC or C horizons, formed from unconsolidated parent material, usually on hillslopes.

R Horizon Continuous, unweathered sediment or bedrock.

Reg Soil A soil with ABC, AC or ABR horizons. Veneered by desert pavement and containing at shallow depth gypsic, salic or calcic horizons. It developes from coarse desert alluvium or colluvium, under an arid to extremely arid climate.

Riser A steeply sloping surface of one of a series of natural step-like landforms, as those of successive stream terraces.

Sabkha A term used on the Arabian Peninsula for a salt flat or low salt encrusted plain restricted to a coastal area, as along the Persian Gulf.

Saddle A low point on a ridge or crest line, generally a divid between the heads of streams flowing in opposite directions.

Sand Soil or sediment particles between 2 and 0.0625mm in diameter. Fine sand <0.250mm.

Sandstone A cemented or otherwise compacted detrital sediment composed predominantly of quartz grains, the grades of the latter being those of sand.

Sandy Regosol A deep soil with AC or C horizons formed from unconsolidated sand. A horizon is light in color and contains small amount of organic material.

Sandy Soil Sandy soil is a soil which includes sand as a major textural component. Such soil is rather diversified according to the pedogenic processes involved.

sa — Salic Horizon A soil horizon with a visible secondary concentration of soluble salts (frequently chlorides), usually containing more than 2% of salts.

Serozem Soil A soil with ABC or ABB_b horizons, usually light in color. Contains at shallow depth a calcic and/or gypsic horizons.

Shale A fine grained sedimentary rock, formed by the consolidation of clay, silt or mud. It is characterized by finely laminated structure, which imparts a fissility approximately parallel to the bedding. It normally contains at least 50% silt with 35% "clay or fine mica fraction" and 15% chemical or authigenic materials. It is generally soft but sufficiently indurated.

Sieve Deposit Coarse grained lobate masses on an alluvial fan and talus whose material is sufficiently coarse and permeable to permit complete infiltration of water and dust.

Silt A soil or sediment separate consisting of particles between 0.0625 and 0.002mm in (equivalent) diameter. Fine silt – <0.016mm.

Soil Horizon A layer of soil differing from adjacent genetically related layers in various properties (physical, chemical, biological, structure, texture, color).

Soil Profile A soil profile consists of the vertical arrangement of all the soil horizons (q.v.) down to the parent material.

Soil (Deposit) Texture see: Texture of Soil, Deposit.

Solonchak A soil containing high quantities of salts especially in the upper horizons. Develops in playas and sabkhas where saline groundwater level is shallow.

Talus Talus is here defined as a debris mantle on a hillslope or at its foot, formed by rockfall, slope wash, debris flow or creep. It assumes different/various forms: an apron at the foot of a cliff; a cone at the mouth of a gully or a small ravine.

The types of talus slopes in the present report are: rockfall talus, debris flow (q.v.) talus, paved (by desert pavement, q.v.) talus and sieve deposit (q.v.) talus.

Takyr A fine textured soil developed on a playa surface without a watertable close enough to the surface to permit salt crust to appear. It usually has a slightly to moderately saline subsoil.

Terrace — Alluvial, Rock-cut An abandoned, inactive, stream channel, flood plain or alluvial fan.

Alluvial Terrace — a stream terrace composed of unconsolidated alluvium.

Rock-cut Terrace — a terrace, usually cut by a stream in bedrock.

Tertiary The first period of the Cenozoic era, between the Mesozoic and the Quaternary; covered the span of time between 6.5 and 1.8 million years ago. It is subdivided into five epochs: the Paleocene, Eocene, Oligocene, Miocene and Pliocene.

Texture of soil or deposit A measure of the size of the particle components and the particle size distribution (see figure C.1.1,c in chapter C.1).

Tread The flat or gently sloping surface of one of a series of natural step-like landforms, as those of successive stream terraces.

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G.5 PLATES

PLATE 1

A Typical landforms of dissected limestone terrains (northen Negev):

(1) Crest.
(2) Rocky hillslope.
(3) Interchanging rocky scarplets with loess covered benches.
(4) Colluvial footslope.
(5) Dissected colluvial – alluvial fill.

B A portion of the Negev on a satellite imagery. Note several broad landscape types:

(1) Loessial terrains.
(2) Dune fields.
(3) Dissected limestone terrains.
(4) Alluvial plains.
(5) Limestone plateaus.


1
2
20m


B
4
5
2
N
0
10km
NEGEV

PLATE 2

A A stabilised sand dune (1) overlain by an active climbing dune (2).

Mt. Qeren, northwestern Negev.

B An active dune with ripples climbing over the ruins of Bysantine Re<u>h</u>ovot in the northwestern Negev.

C Longitudinal dunes along the coast of northeastern Sinai.

D Loess overlying chalk in the northen Negev.

Note the thicker loess mantle on the north facing hillslope (righthand side of the photo).

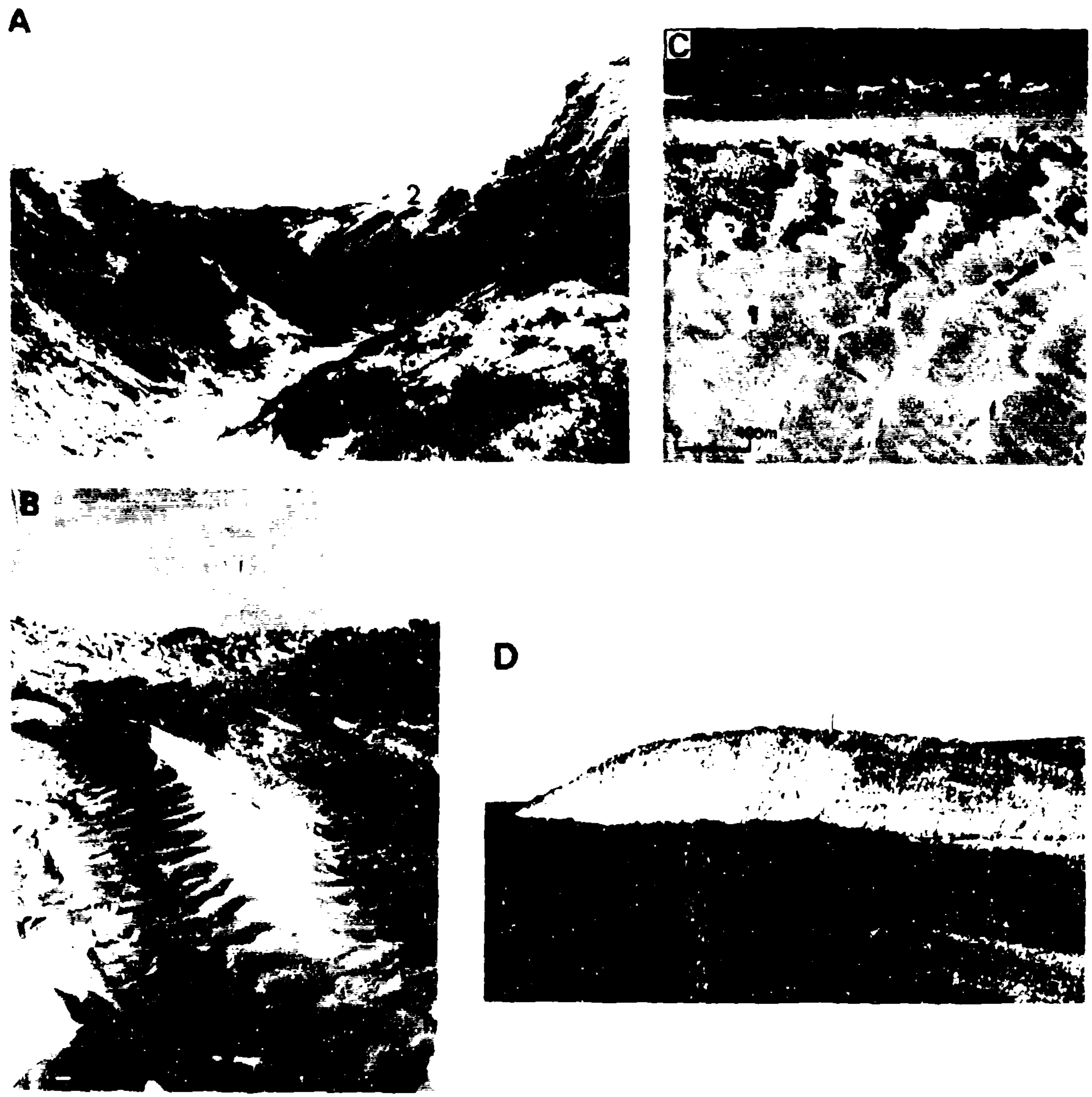

A
2
C
B
D

PLATE 8

A The playa of Qa En-Naqb, southern Negev, surrounded by alluvial fans. Takyr soils characterise the playa surface.

B A playa bordered by alluvial fans (southern Arava Valley).

(1) Old alluvial fans mantled by Reg Soils.
(2) Active alluvial fan — sand and gravel.
(3) Outer playa zone (vegetated) — silty sand and sand.
(4) Transition zone — sandy silt, saline and gypsiferous.
(5) Inner playa zone — sandy and silty clay, highly saline and gypsiferous.

C Soft, puffy and wet silty-clayey playa surface.

Avrona playa, southern Arava Valley.

D Soft, puffy, highly saline and sterile inner playa zone.

Avrona playa, southern Arava Valley.

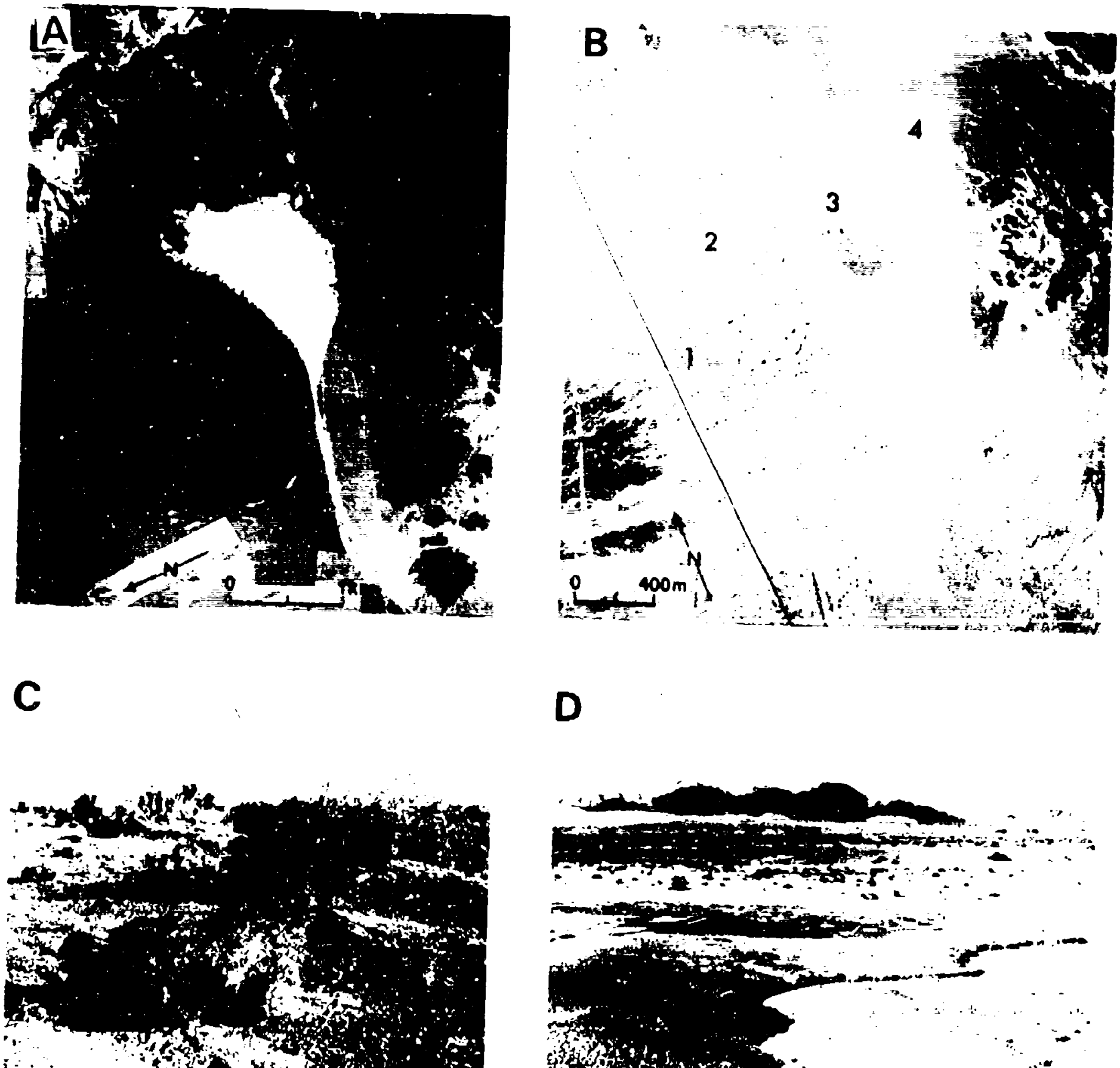

A
N
0
B
4
3
2
1
N
0
400m
C
D

PLATE 4

A (1) Alluvial surfaces of different Quaternary ages mantled by Reg soils.
(2) The extensive playa of Al Jafr.

Southern Jordan.

B Holocene alluvial surfaces of Nahal Hever, draining into the Dead Sea.

C Alluvial surfaces of different ages:

(1) Pleistocene surfaces with a well developed desert pavement over a smooth surface.
(2) Holocene surfaces with a gravel bar and swale morphology.
(3) Active floodplain.

Timna Valley, southern Negev.

D Dissected alluvial fans with rounded and narrow ridges – ballenas.

Nahal Roded, southern Arava Valley.

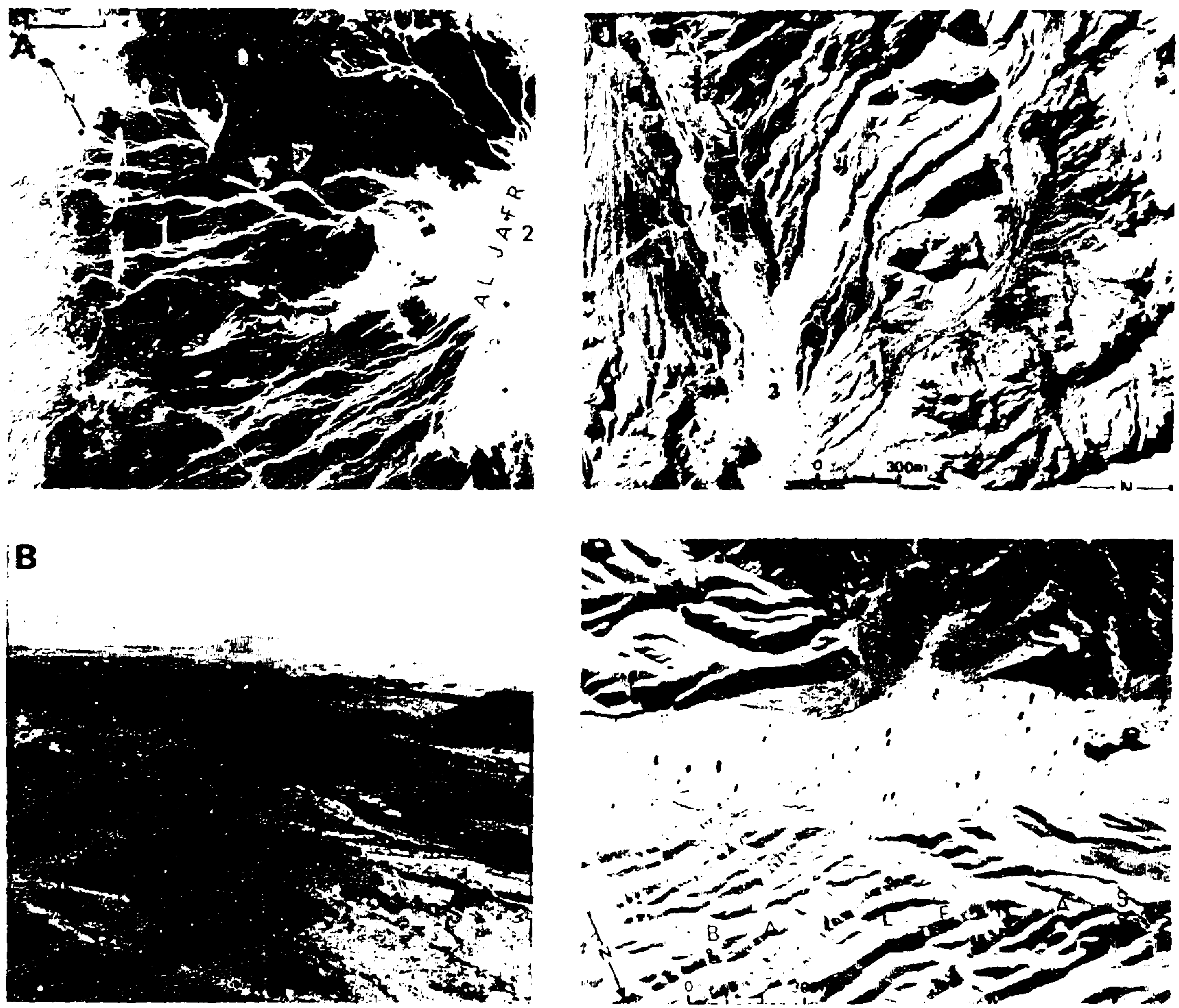

A
N
AL JAFR
2
3
0
300m
N
B
BALLEKA 5
N
0

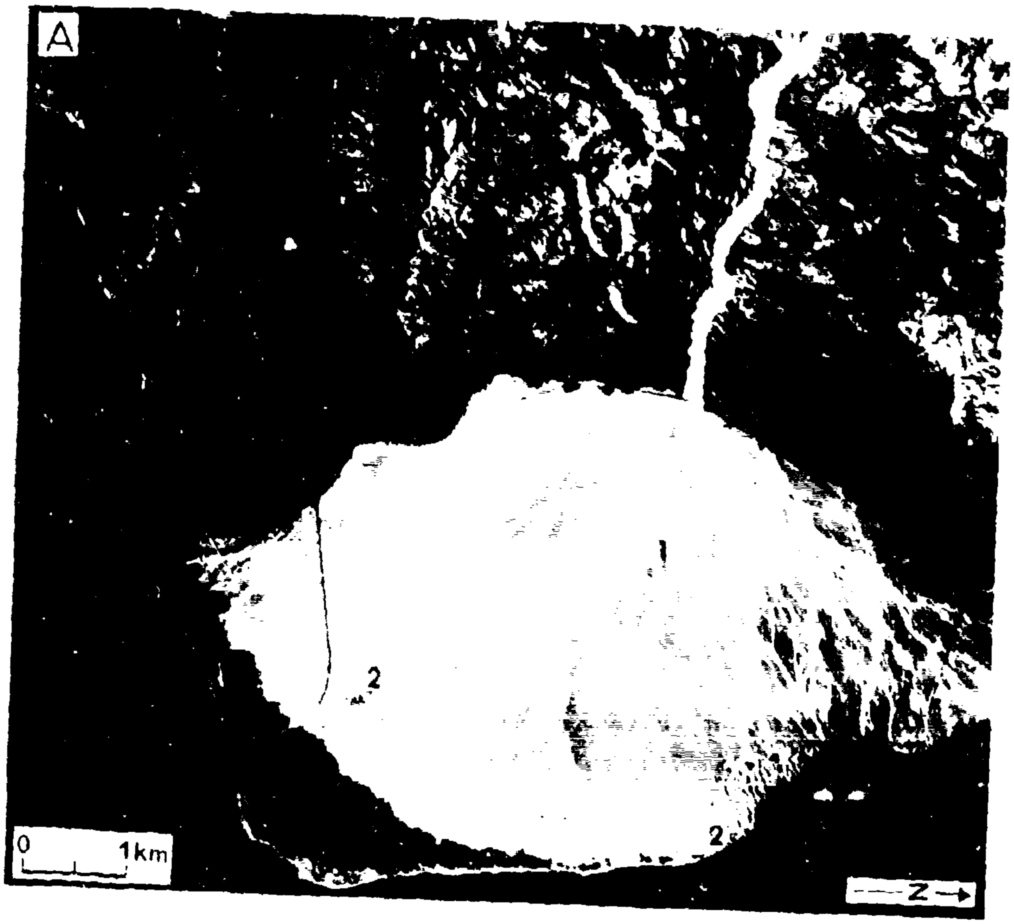
PLATE 5

A The complex alluvial fan of Wadi Wattir, eastern Sinai:

(1) Alluvial fan composed primarily of gravel and sand.
(2) A belt of active sand dunes.
(3) Coastal sabkha.

B Surficial patterns of alluvial fans (Eastern Sinai):

(1) Pleistocene surfaces, smooth with a well developed desert pavement.
(2) Holocene surfaces with well preserved gravel bars and swales.
(3) Active floodplains.


A
1
2
2
0 1km
Z

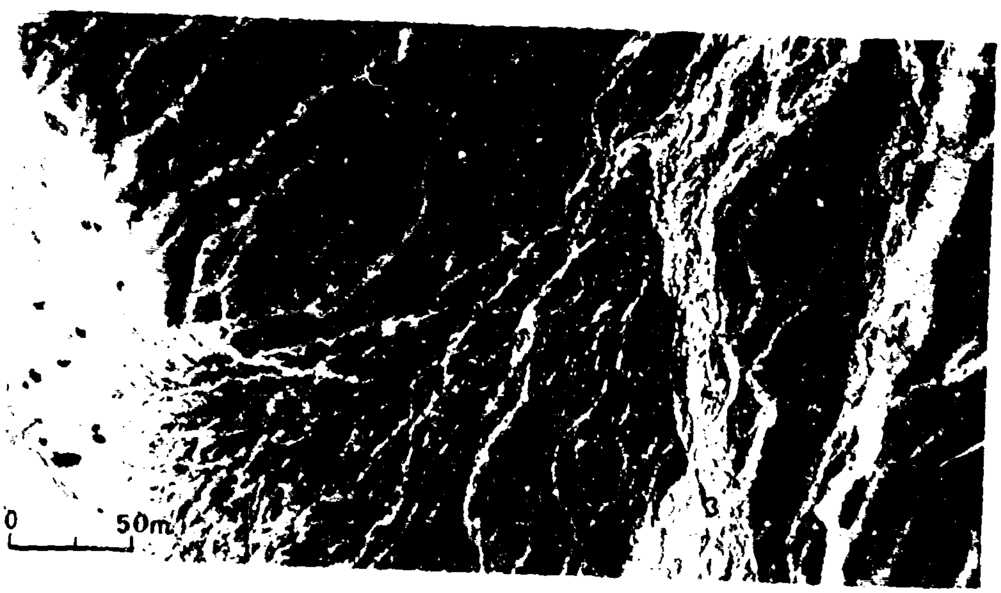

0 50m
3

PLATE 6

A Debris flow fan surfaces of Holocene age, composed of sieve deposits. South of Wadi Mukeibila, eastern Sinai.

B A debris flow fan of Holocene age, composed of sieve deposits. Eastern Sinai.

C Recently deposited sieve deposits. Wadi Naseb, eastern Sinai.

D A recently deposited debris flow with sieve deposits at the surface. Wadi Naseb, eastern Sinai.

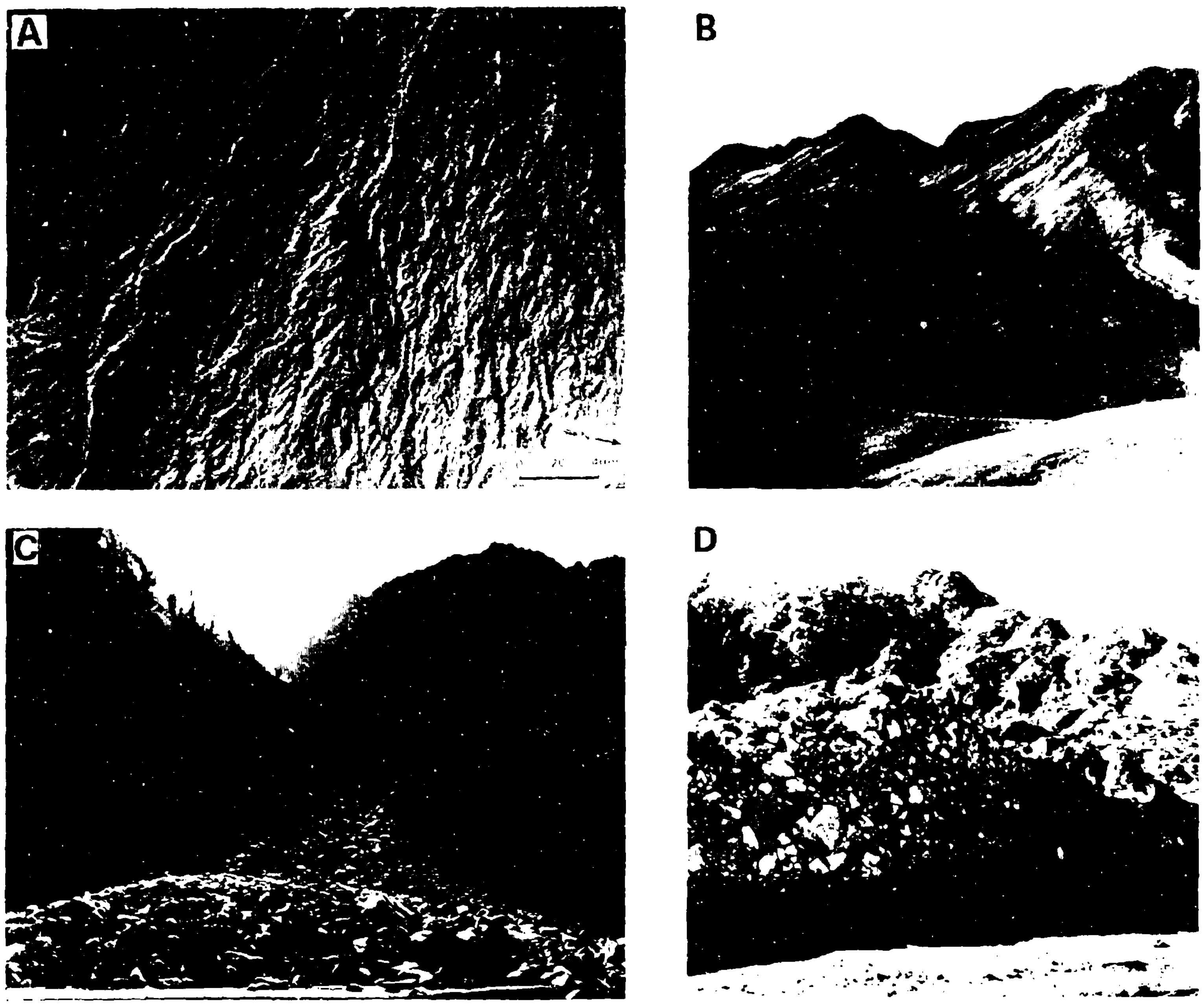


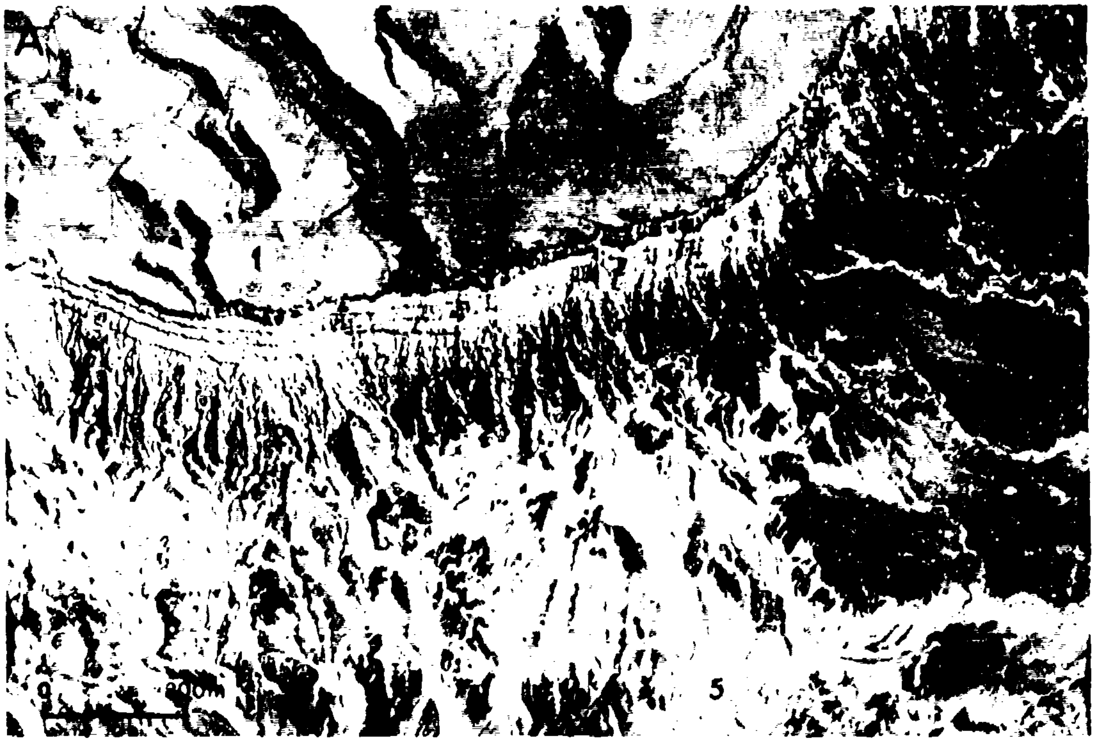
PLATE 7

Some landforms associated with major escarpments:

A (1) A plateau with Hammada soils.
(2) Talus relicts, composed of debris flow deposits mantled by Reg soils.
(3) Transition between talus and bajada, mantied by Reg soils.
(4) Middle Pleistocene alluvial fan terraces with Reg soils.
(5) A late Quaternary alluvial fan terrace with Reg soil.

Makhtesh Ramon, central Negev.

B An active talus slope. Note recently active debris flows. South of Wadi Mukeibila, eastern Sinai.


A
1
5
0
200m


B

PLATE 8

A (1) Hillcrest flat with Hammada soil.
(2) Limestone benches with loessial Serosem soils and Lithosols.
(3) Footslope colluvium with calcic and gypsic lossial soils.

Nitsana area, western Negev.

B An undulating high plateau. The soils are highly clayey and calcic.

(1) Hammada soil.
(2) Clayey, calcic loessial soil.

Mt. Katerina, southern Sinai.

C Talus slopes composed of rookfall debris and sieve deposits. The bedrock lithology is rhyolitic quartz porphyry.

Mt. Amram, Southern Negev.

D Talus slopes at the foot of a large scarp. The taluses are composed of debris flow, rockfall and washed grus deposits. The bedrock lithology is coarse crystalline granite.

Santa Katarina area, southern Sinai.

E Talus slopes, composed of debris flow and rockfall deposits:

(1) An active talus.
(2) A talus relict mantled by talus Reg soil. Bedrock lithology is flint and marl layers (Sayarim Formation) overlying chalks (Menuha Formation).

Southern Arava Valley margins.

F Talus slopes composed primarilly of debris flow deposits.

Note recent debris flows on the upper part.

Wadi Mukeibila, eastern Sinai

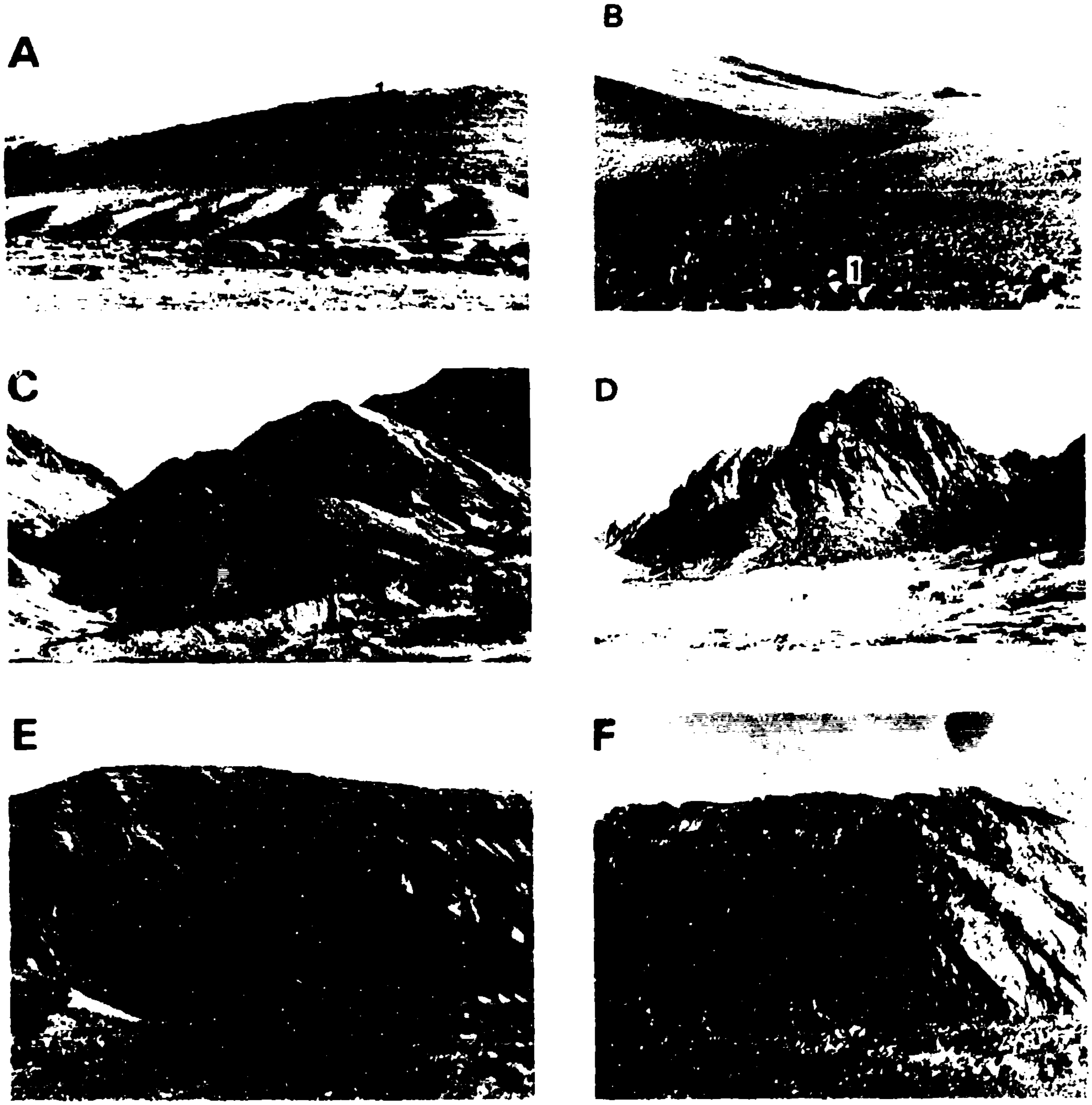

A
B
1
C
D
E
F

PLATE 9

Densely dissected and badland terrains:

A Loess and loessial soils in the southern coastal plain in Israel.

B Chalks and shales of the Lisan Formation in the northern Arava Valley.

C Marls and shales in the Zin Valley, northern Negev.

D Chalks overlain by flint, northen Negev.

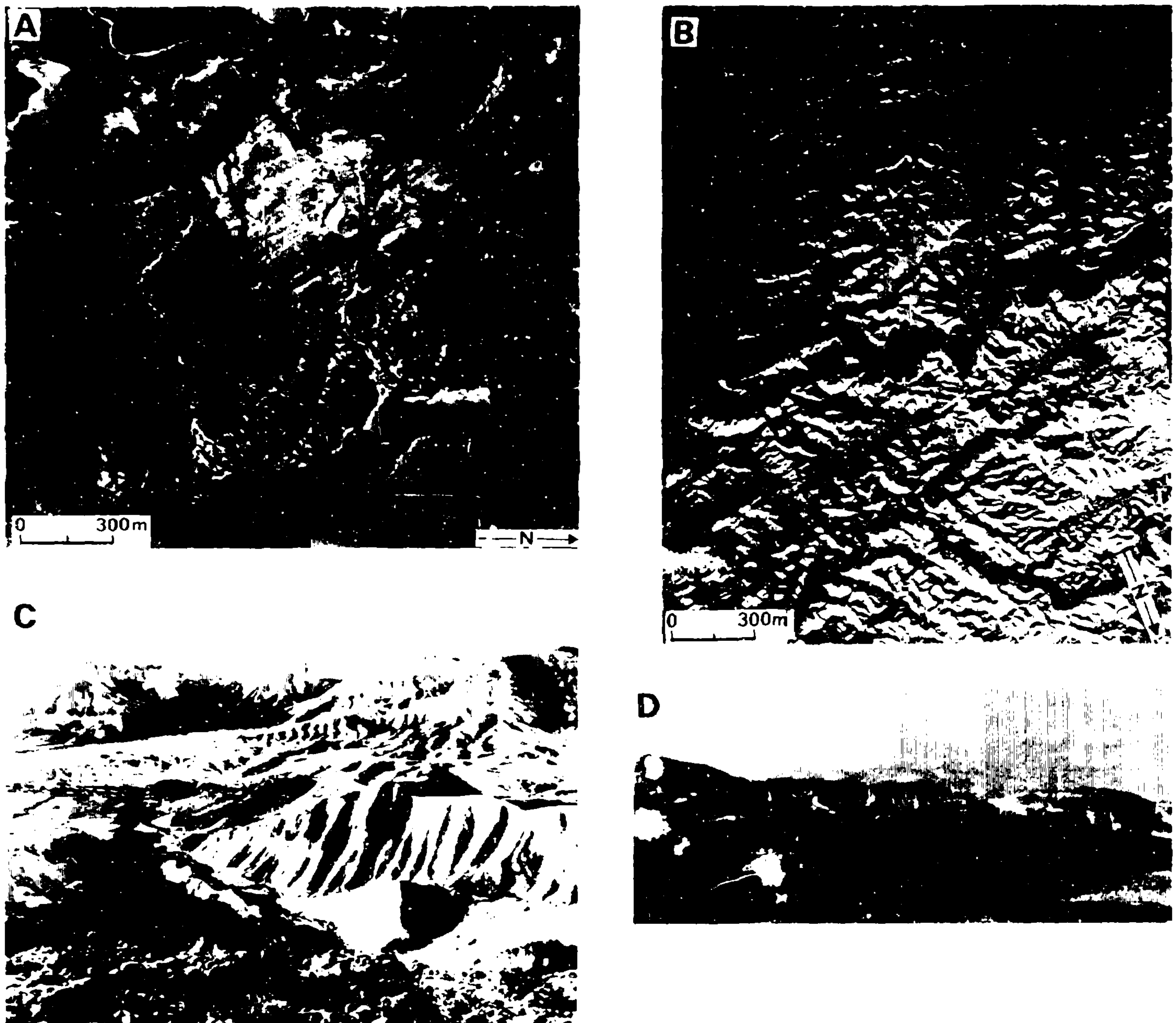

A
0 300m
N
B
0 300m
N
C
D

PLATE 10

A Round structures of an archaeological site of Middle Bronse I Age (-4000 years old). The structure is partly filled with eolian dust.

Nitsana Site, western Negev.

B A cut in a Middle Bronse I house, partly filled with eolian dust and collapse stones.

Be'er Resisim, western Negev.

C A cut in a dust and gravel fill of an Early Bronse archaeological site (-4500 years old).

Tel Arad, northern Negev.

D Stratified fluvial loess and gravel fill behind a dam.

Western Negev.

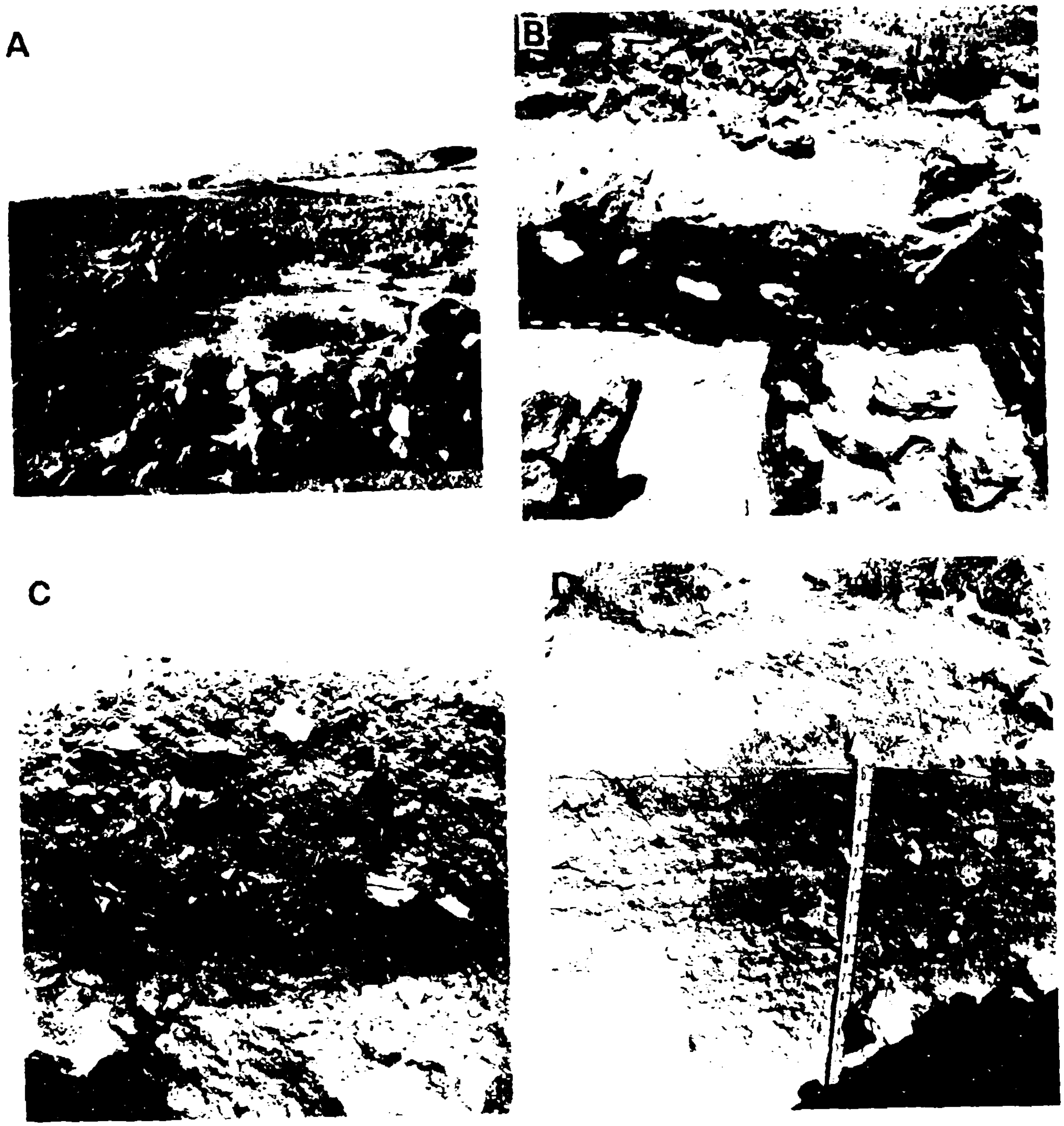

A
B
C
D

PLATE 11

A A well developed Hammada soil on a limestone plateau. A complete cover of desert pavement overlying a gravel-free B horison.

Southern Negev

B A Hammada soil profile on a quarts prophyritic bedrock. A complete, well developed, desert pavement cover; a silty vesicular A horison (1 cm thick); the C horison (30 cm thick) is composed of mechanically weathered gravel, with highly saline and gypsyferous silty sand (including gypsic gravel coatings).

Mt. Amram, southern Negev.

C A young Takyr soil in the southern Negev, composed of silt-loam.

D A Pleistocene Reg soil in eastern Sinai: a gravel-free B horison and a highly gypsiferous and saline C horison. Note the gypsic pebble coatings.

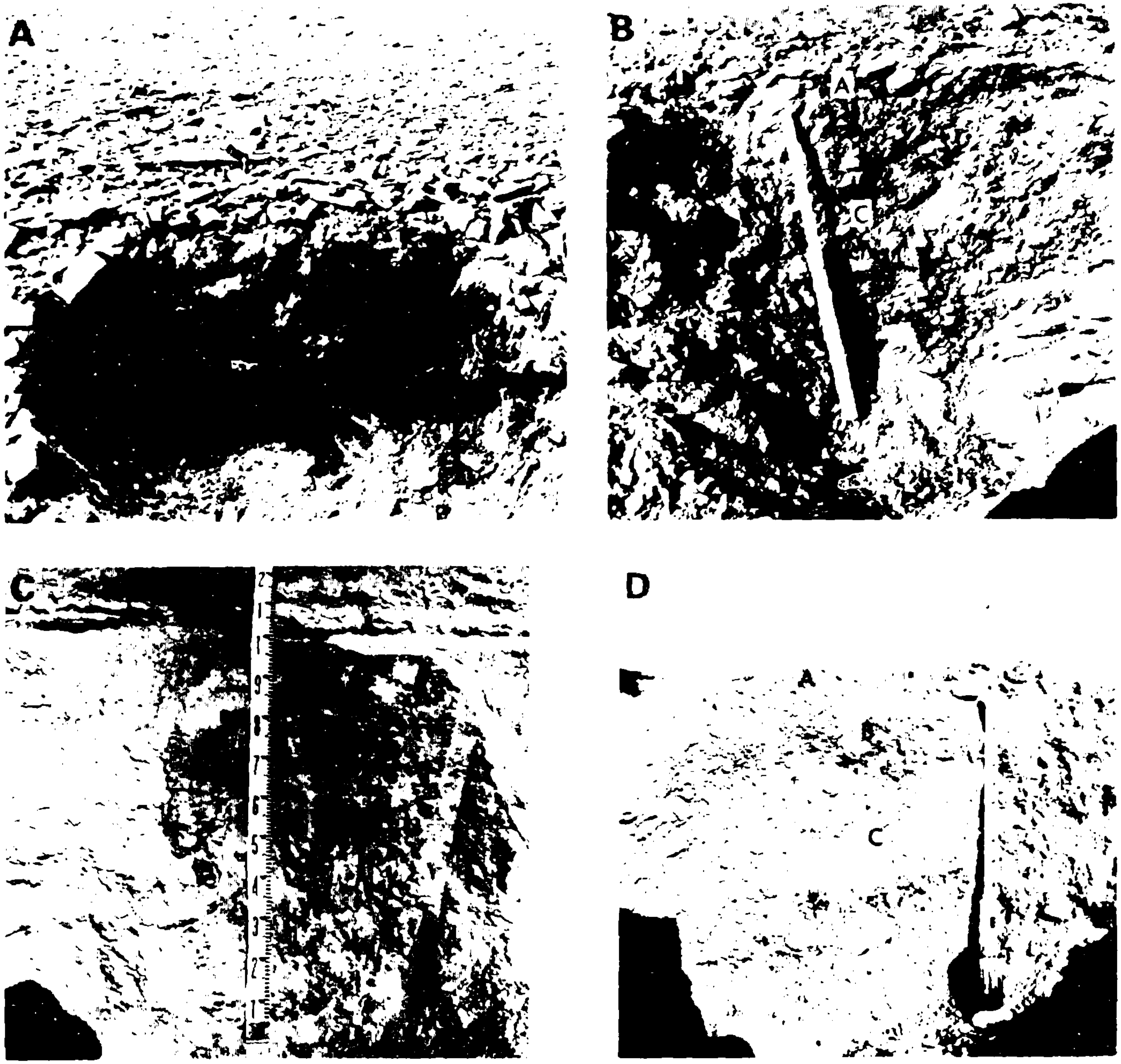


PLATE 12

A Stratified alluvium in a Holocene terrace, composed of gravel and sand.

Mt. Amram, southern Negev.

B Stratified and cross-bedded fluvial (1) sands and (2) silty loams.

East of Yotvata, southern Arava Valley.

C Gypsum coating of cobbles in a Pleistocene Reg soil.

Timna Valley, southern Negev.

D Discontinuous gypsum coating on gravel in the C horizon of a latest Pleistocene - early Holocene Hammada Soil.

Mt. Amram, southern Negev.

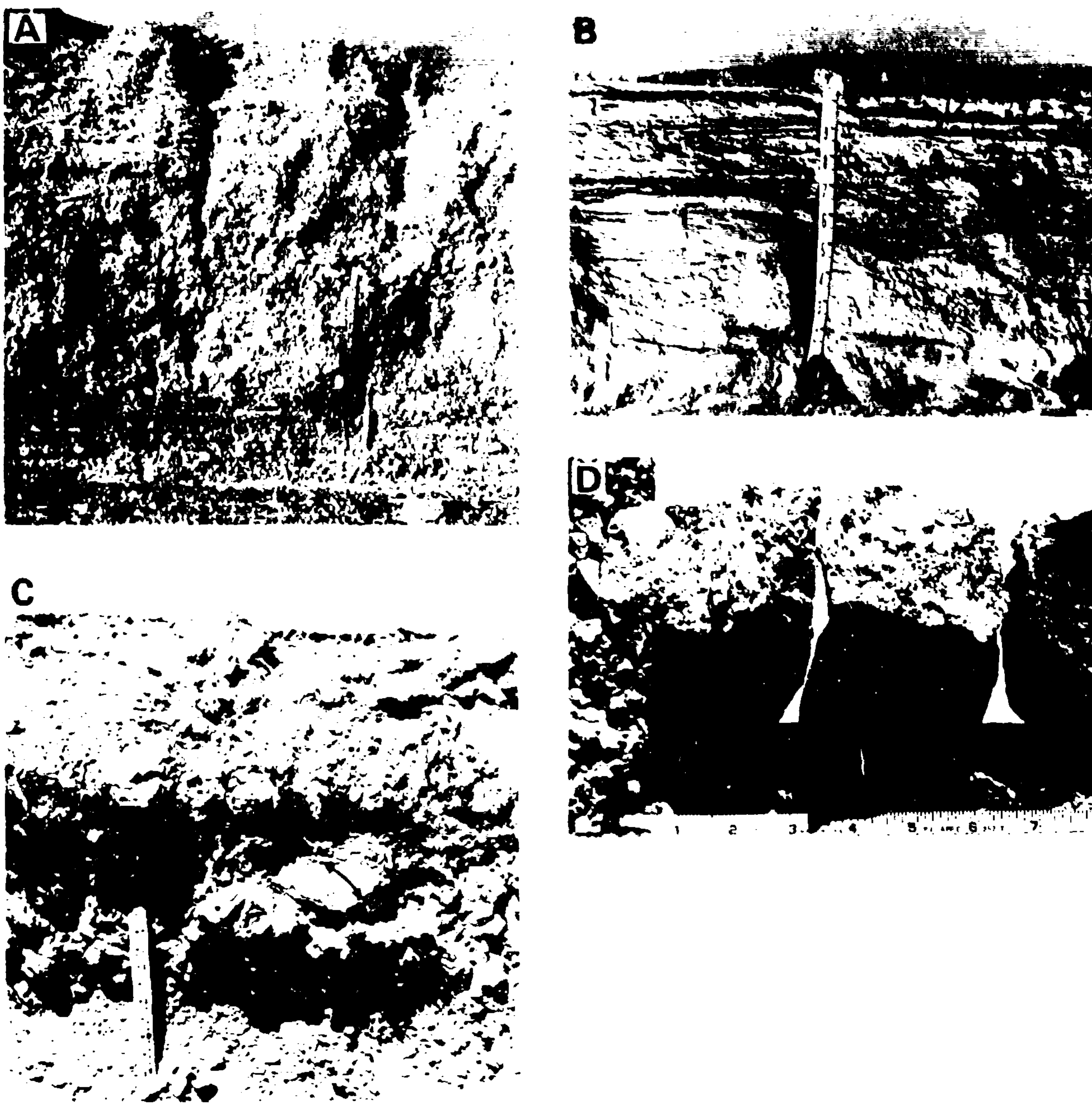

A
B
C
D

PLATE 13

A An early Holocene Reg soil: a locally well developed desert pavement overlying a thin vesicular silt-loam A horizon (0.5 cm thick). B horizon is gravelly and slightly saline. C horizon is highly gravelly, gypsiferous and saline. Note the mechanically weathered gravel in the C horizon.

Naḫal Ze'elim, western Dead Sea.

B An early Holocene Reg soil in Timna Valley, southern Negev. The vesicular A horizon is 1.0–1.5 cm thick; B horizon is 5–10 cm thick and highly silty; C horizon is gypsiferous and saline, with a high proportion of salt weathered gravel.

C A Pleistocene Reg soil on a high terrace of Wadi Sa'ade, eastern Sinai. Note the difference between the highly gypsiferous right hand side and the far less gypsiferous left bank side of the C horizon.

D An old polygenetic Reg soil on a late Tertiary surface. A thick layout gravel-free silt loam A and B horizons, is overlain by a well developed desert pavement. Paleocalcic and paleogypsic horizons are observed below depth of 70 cm.

E A late Pleistocene Reg soil with a petrogypsic horizon in the southern Arava Valley.

F A mottled calcic paleosol burried under a later loessial cover in Naḫal(=wadi) Nitsana, western Negev.

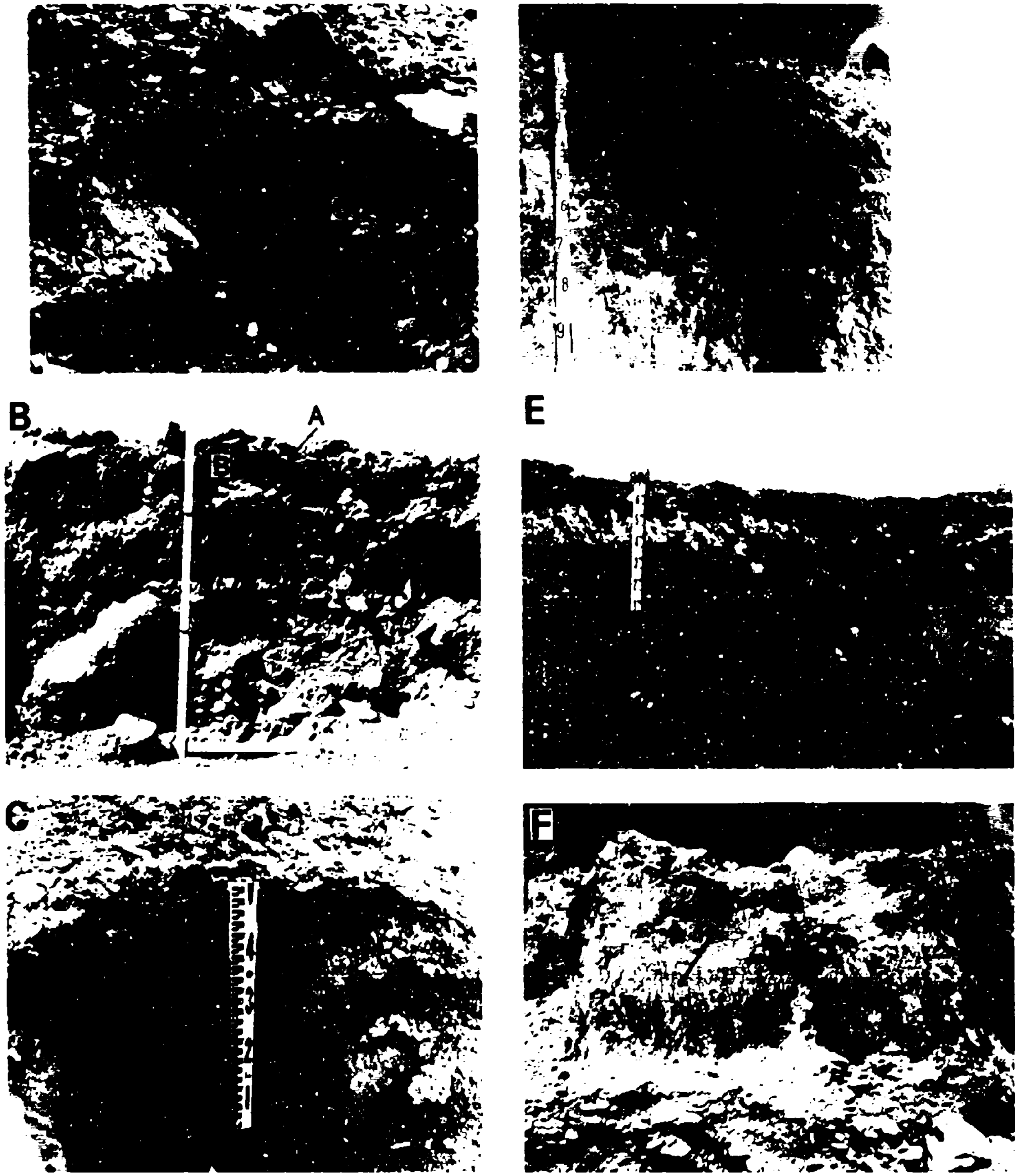

B
A
B
E
C
F

PLATE 14

A A gravelly surface of an early Holocene alluvial fan. An early stage of desert pavement development.

Wadi Mukeibila, eastern Sinai.

B A well developed desert pavement.

Nahal (=wadi) Nitsana, western Negev.

C Plates of sandstone over sand and bedrock.

Southern Sinai.

D A typical Hammada surface:

(1) Limestone bedrock, in situ.
(2) Desert pavement over Hammada soil in pockets.

Western Negev.

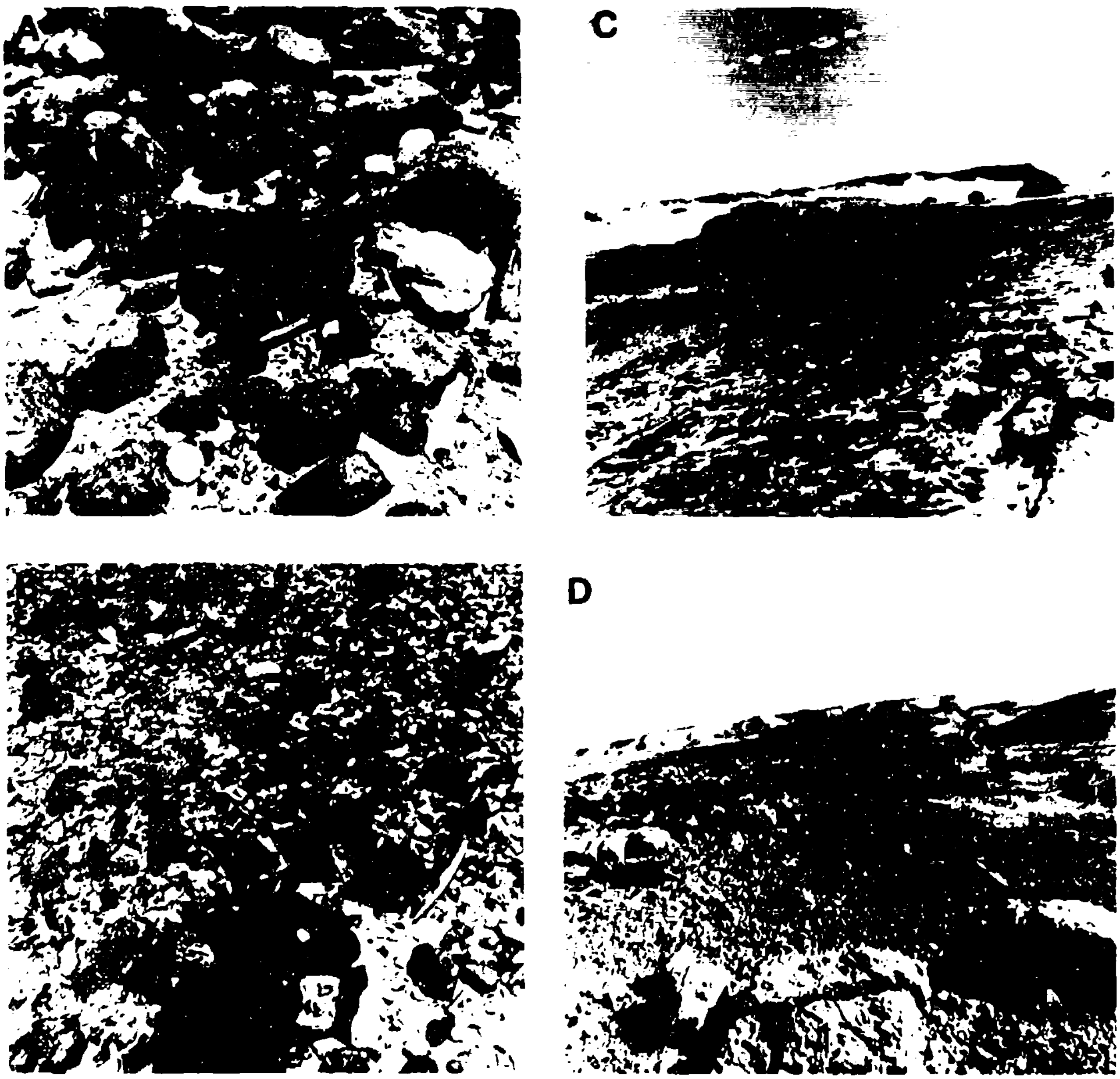

A
C
D

PLATE 15

A Encrusted debris mantle on shales. The crust is composed of 60–70% clay, 30–40% silt, and minor amounts of fine sand (< 5%).

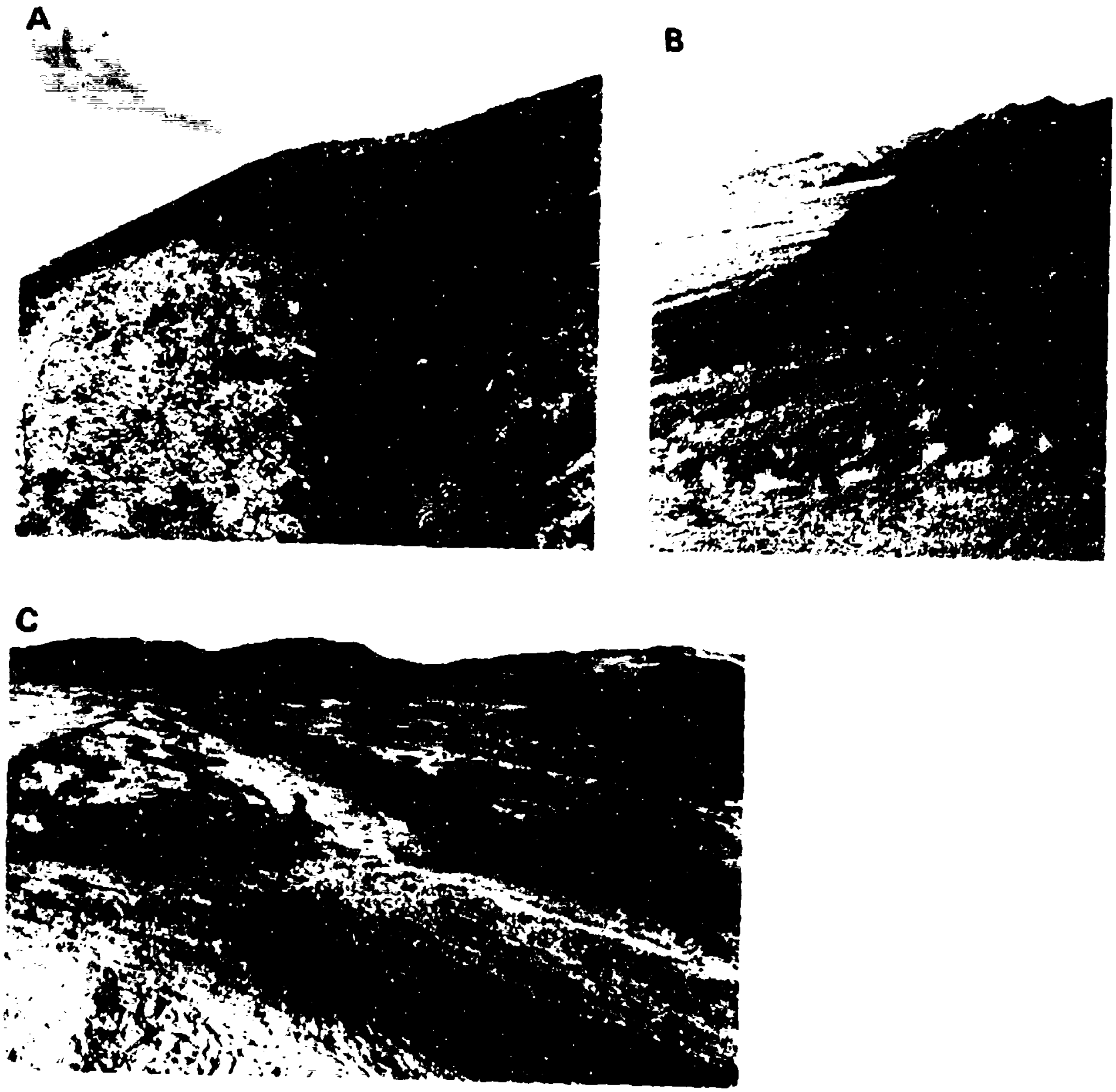
Northern Negev.

B Fine angular gravel is sieve deposited in an active alluvial fan.

Mt. Amram, southern Negev.

C A loamy crust deposited on an active floodplain.

Biq'at Uvda, southern Negev.


A
B
C